

747

CAVES of MULU



CAVES OF MULU

**THE LIMESTONE CAVES
OF THE GUNONG MULU NATIONAL PARK
SARAWAK**

Edited by
D. B. Brook and A. C. Waltham

Royal Geographical Society — Sarawak Government Expedition
1977—78

Published by
The Royal Geographical Society, London, SW7 2AR

1978
Reprinted 1979



Flowstone lake midway along Revival in Clearwater Cave

CAVES OF MULU

Contents

The Gunong Mulu Park	..	5
The Caves and their Exploration	..	6
Gua Payau	..	9
Lubang Sungai Payau	..	11
Lubang Darurat	..	11
Lubang Ular	..	12
Lubang Hijau	..	12
Lubang Angin	..	15
Gua Air Jernih	..	16
Sendirian	..	25
Gua Harimau	..	26
Lubang Ramalan	..	27
Gua Ajaib	..	28
Lubang Rendah Harimau	..	33
Gua Sungai Terikan	..	34
Bukit Lubang	..	38
The Origin of the Caves	..	39
The Cave Life	..	41
Acknowledgements	..	44

© The R.G.S. Mulu Expedition Speleological Team
Dave Brook Phil Chapman Andy Eavis
Mike Farnworth Ben Lyon Tony Waltham

Cover Photographs: Front: Clearwater Cave, Main River Passage
Back: Pinnacles, over 100 feet tall, on Gunong Api



Looking east across the dolines and pinnacles of Api, the cliffs in the distance plunge into Hidden Valley

THE GUNONG MULU PARK

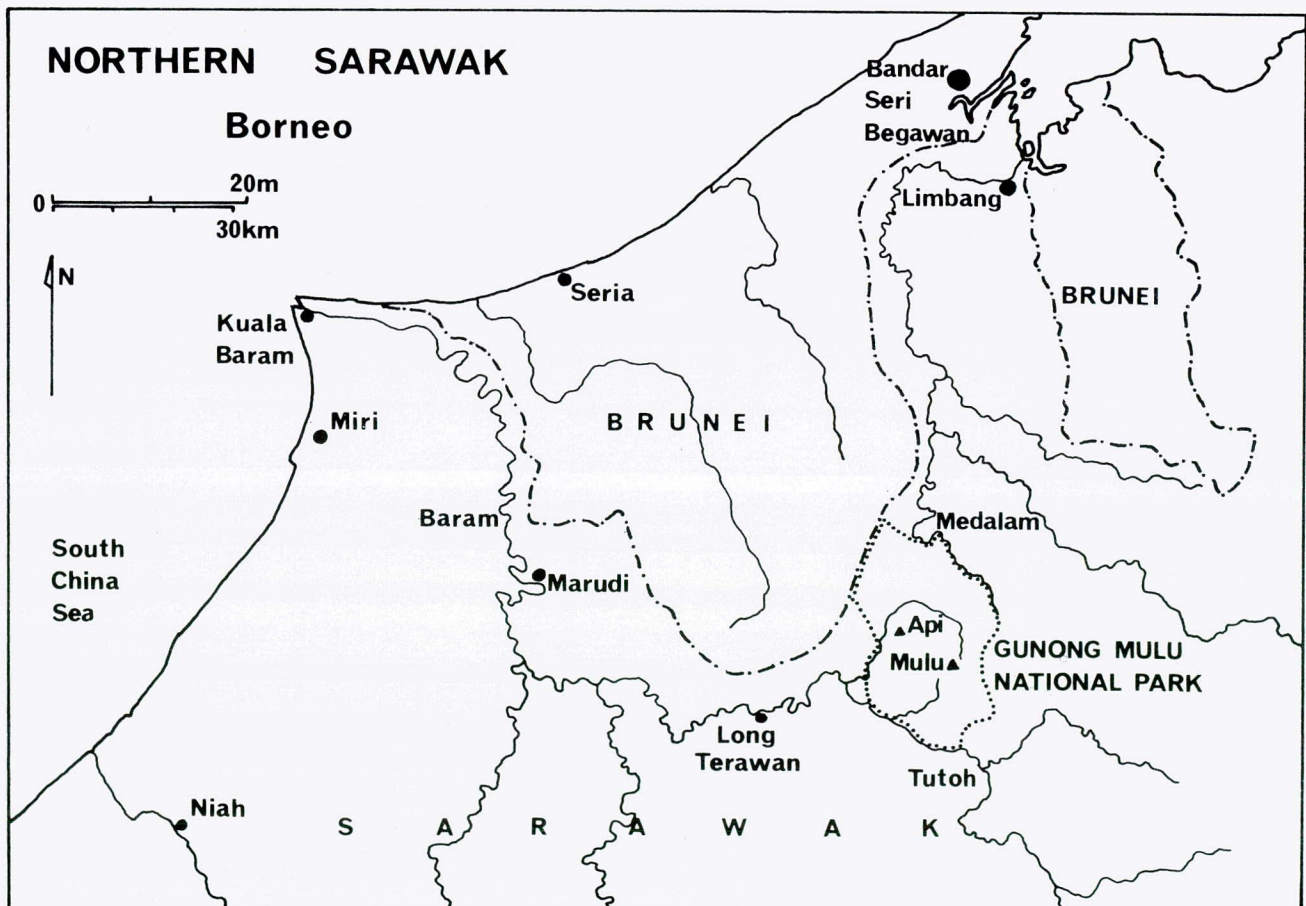
Located near the northern corner of Sarawak, the Gunong Mulu National Park contains some 200 square miles of rain forest spread over flat plains and towering mountains. The park was established in 1975 as a conservation and study sample of this uniquely fascinating environment. It is unpopulated, save for a small number of Penan nomads, and it still offers a relatively unexplored and untouched landscape.

Most of the southeast half of the park is occupied by Gunong Mulu itself, a sandstone mountain rising to nearly 8000 feet. Across the centre lie the limestone ridges culminating in Gunong Api, and north of these is low lying land – mostly the alluvial plain drained by the Melinau and Terikan Rivers. The whole area is clad in luxuriant rain forest as the park's climate provides it with close to 400 inches of rain per year and temperatures which rarely range beyond 70-90°F.

Access to the western borders of the park is facilitated by the Rivers Tutoh and Melinau, both partly navigable by longboats. From the Melinau, footpaths reach to the summit of Mulu, Deer Cave and the Melinau Gorge. Beyond them there are many Penan trails and the alluvial forest is thin enough for easy walking, but progress on the mountains is a much more serious proposition.

By far the most spectacular landscapes of the park are provided by the limestone hills. Vertical white cliffs tower 2000 feet above the alluvial plains and alternate with incredibly steep, forest clad slopes. The higher levels of the hills are almost unexplored and unexplorable, save for a very few hard-won trails. Deep dolines abound, vertical cliffs are recurring features, and the pinnacle karst is one of the most inhospitable terrains known to man. However, this does all add up to one of the world's most spectacular limestone landscapes, and the pinnacles, some of them more than 100 feet tall, represent a classic feature of tropical karst.

Complementing both the scale and spectacle of the park's surface karst are the caves deep within the limestone. They are all described in the following pages and together they comprise one of the most remarkable groups of caves in the world. Clearwater Cave is the longest known outside Europe and North America, Wonder Cave is fabulously decorated, and Deer Cave has possibly the largest cave passage in the whole world. The caves of Mulu are amazingly spectacular and provide yet another facet to a truly magnificent National Park.



THE CAVES AND THEIR EXPLORATION

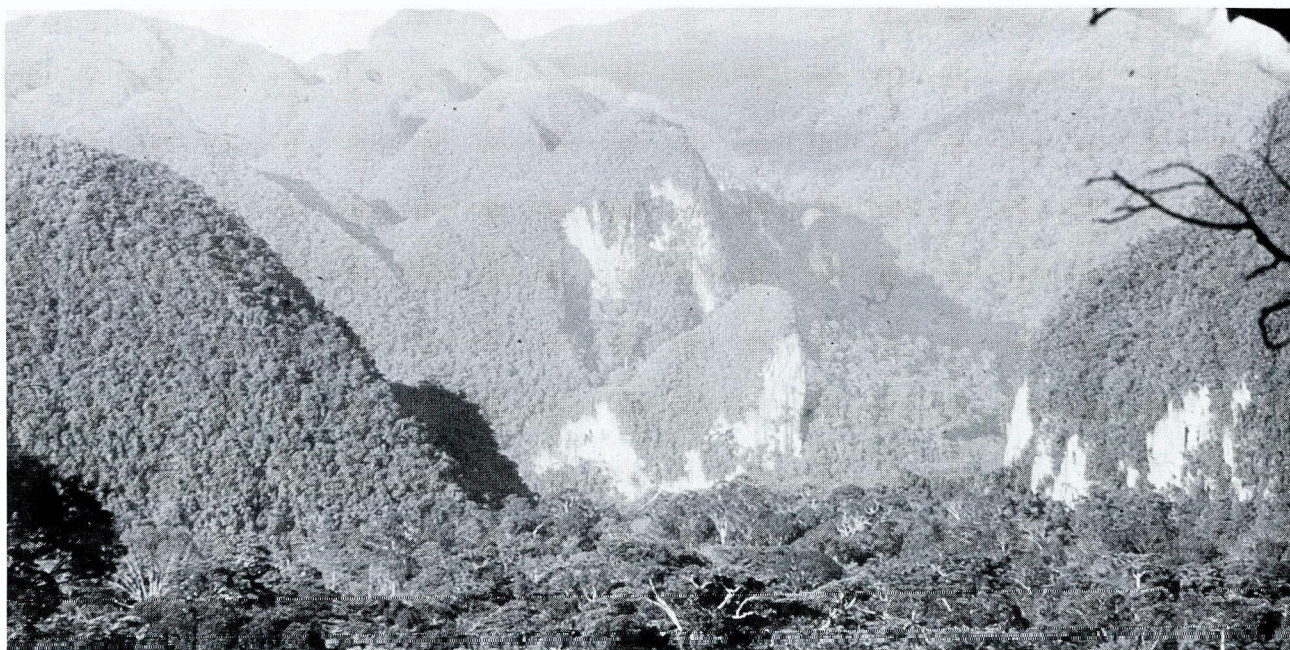
Lubang China is the name given to a short cave which engulfs the River Terikan as it passes through a small limestone hill half a mile west of its source in Gunong Benarat. It was inadvertently explored by two Chinese washed into it in their boat early in the last century. Unfortunately they drowned in the sump only a few yards from daylight. And it was only the next "outside" visitor to the Mulu area, Spenser St. John in 1856, who first recorded the existence of large caves in the limestone hills. Even so, the local people – both Penans and Berawans – must have long known of Deer Cave, located at the accessible end of the limestone. This they entered long ago, but most other caves they only know as entrances.

In 1961 G. E. Wilford of the Malaysian Geological Survey carried out the first serious cave explorations – a magnificent feat considering the remoteness of the area. He surveyed Deer Cave, the first parts of Cave of the Winds and Tiger Foot Cave, and also three of the inlets to the Terikan River Caves, besides other minor caves. And his published work, on the caves of all Sarawak, alludes to the great potential of the caves in the mountains of Api and Benarat.

It was therefore almost surprising that the caves were not revisited until 1977-8 when the Royal Geographical Society descended on the Mulu region for a 15 months long expedition. During March, April and May 1978, the six-man caving team within that expedition explored and surveyed all the caves now known in the limestones of the Mulu Park – and the results of their work occupy the following pages. Clearwater Cave, with its 16 miles of passage, proved to be the greatest discovery of the expedition, but also notable was the first serious exploration in Hidden Valley, even though the sinking river there could not be followed underground.

Nearly all the caves discovered to date are both enjoyable and ridiculously easy to explore for a competent, experienced caver. On the other hand, fast flowing water, precariously balanced boulder piles, collapsing false floors and unexpected vertical drops provide all the usual underground hazards for the incautious. Wonder Cave is the only one to provide a hard caving trip, though the Solo shaft and the Terikan River Caves each require their own variety of ropework. Flooding is a special hazard. Though this is lessened by the predictability of the daily rainfall pattern the scale of the floods can be monstrous. A seven foot rise in river level can take place in a few hours. The inlet caves draining off the alluvial plain exhibit the most rapid flooding, while the Clearwater River for example has a more delayed flood peak, and most of the fossil caves are permanently safe. One favourable point about the water is its temperature; at close to 80°F it makes the wet caves a joy to explore.

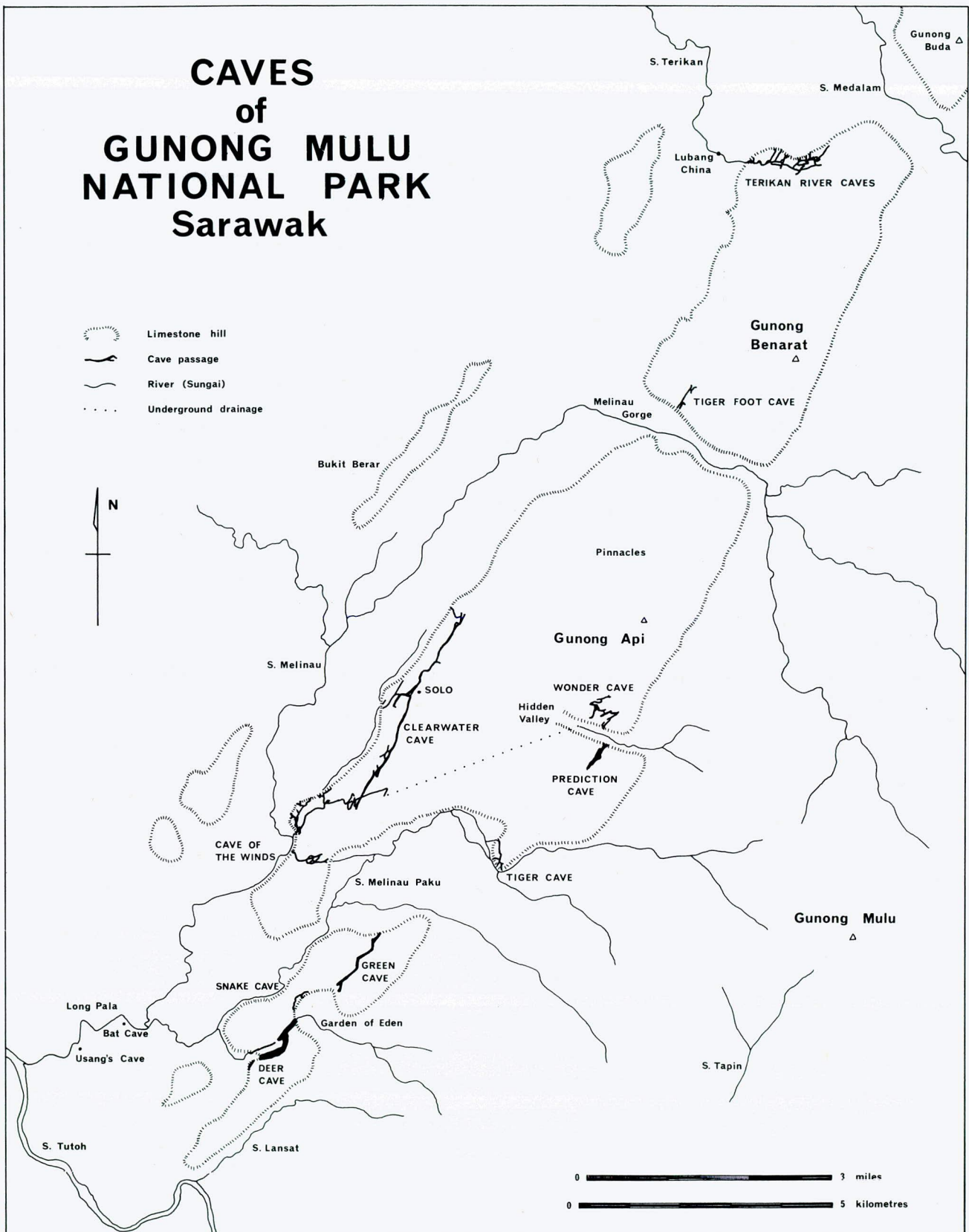
Now known to contain more than 30 miles of cave, including the fabulous Clearwater system and the record breaking proportions of Deer Cave, the Gunong Mulu National Park already ranks as one of the world's great cave regions. Furthermore, the exploration potential has barely been touched and only the largest and most obvious caves have been found. The area may be remote, and walking through the pinnacle karst may be difficult; but once the entrances are reached, the caves are long and spectacular – and many more await discovery.

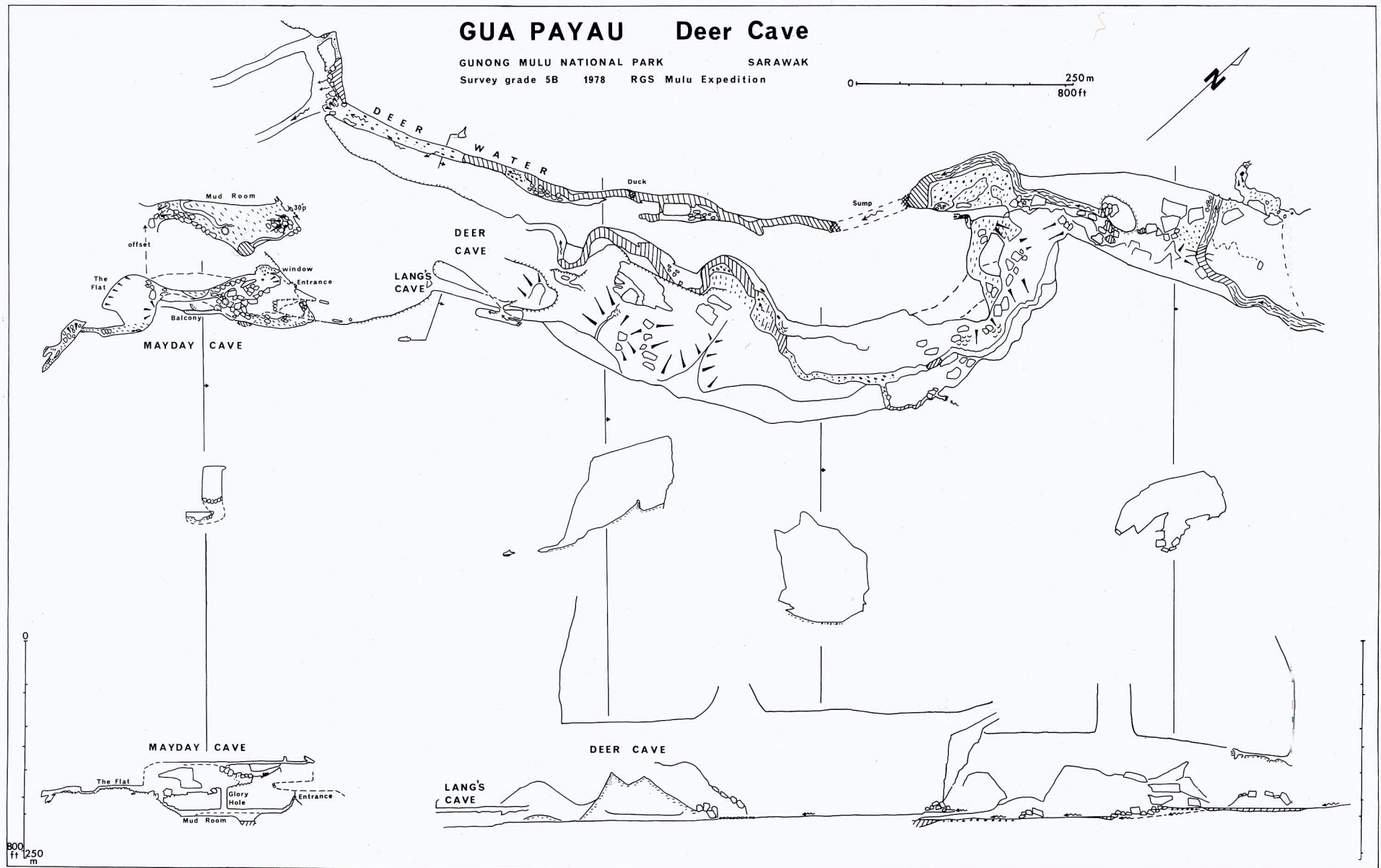


Vertical cliffs more than 1000 feet high break the steep limestone slopes around the Melinau Paku valley

CAVES of GUNONG MULU NATIONAL PARK Sarawak

-  Limestone hill
-  Cave passage
-  River (Sungai)
-  Underground drainage





GUA PAYAU – Deer Cave

Passing right through a limestone ridge east of the Melinau Paku valley, Deer Cave carries the drainage from the Garden of Eden, a spectacular blind valley on the side of Gunong Mulu's west ridge. It is reached by a well used footpath from the Paku and it has been known for many years, really because it cannot be missed. The surveyed length of the cave is 5750 feet, but this ignores endless oxbows and route variations and does not do justice to the size of the passages.

Deer Cave almost defies description. In simple terms it is just one passage passing straight through the hill. But at its downstream end the passage is 570 feet wide and 400 feet high. Through its whole length the cave is nowhere less than 300 feet high and wide, though it is broken by a rock bridge in the centre, and this height does not include the soaring 100 feet diameter avens which break the roof in the upstream half.

Because of its size, daylight penetrates practically the whole cave, which is an immense help in navigating through it. From the downstream end, an easy route on a sand floor follows a small stream round a gigantic debris pile on the right. The cave then opens out into a vast chamber unfortunately marred by some rather odorous guano deposits – though the underground scenery is truly magnificent. Where the cave curves to the left, oxbows, ledges, arches and inaccessible roof passages all complicate the situation and the visitor has to thread his way among enormous fallen blocks. After only a few yards of semi-darkness, the cave opens out again with light streaming in from the upstream entrance. A scramble down over boulders, and a short handline pitch, leads to the river which flows left into a wide sump pool. Upstream the easy route follows the water until a great boulder pile requires yet more scrambling. On the east wall there is a series of high boulder strewn ledges, and also a veritable mountain of guano which rises at its angle of rest for a clear hundred feet. Dry and therefore relatively unobnoxious, this lies beneath an enormous aven which disappears into blackness hundreds of feet overhead and appears to house some of the main roosts of the million or so bats which inhabit this amazing cave.

By any standards, Deer Cave is fantastic. Probably formed by the Melinau Paku long ago, it poses questions as to how the blind valley of the Garden of Eden was developed. And today it is a strong contender for the title of the largest cave passage in the world, which makes a visit to it completely unforgettable.



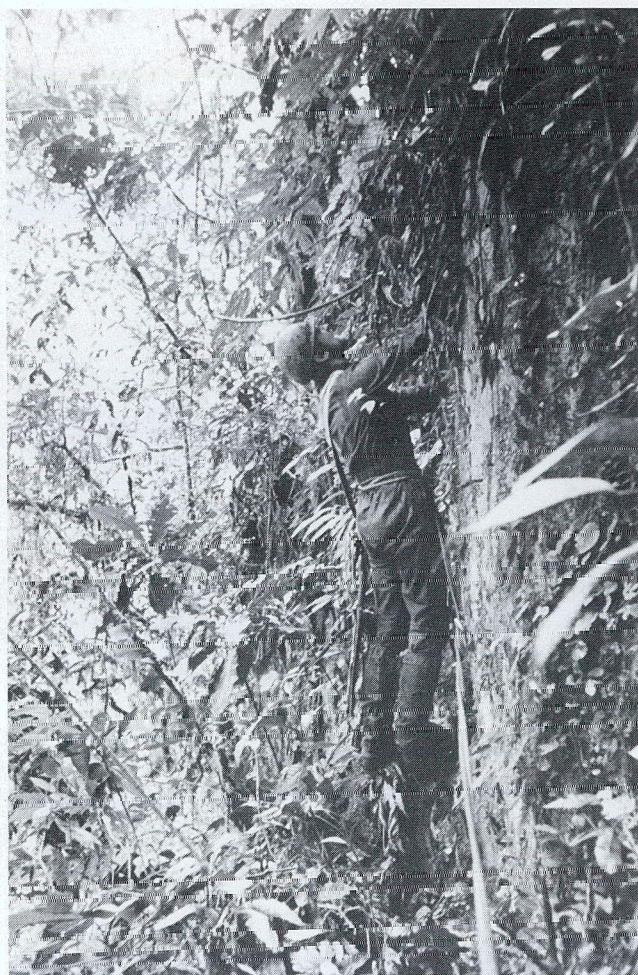
Looking in from the south end of Deer Cave, the vast size is only indicated by the group of eight people (arrowed)



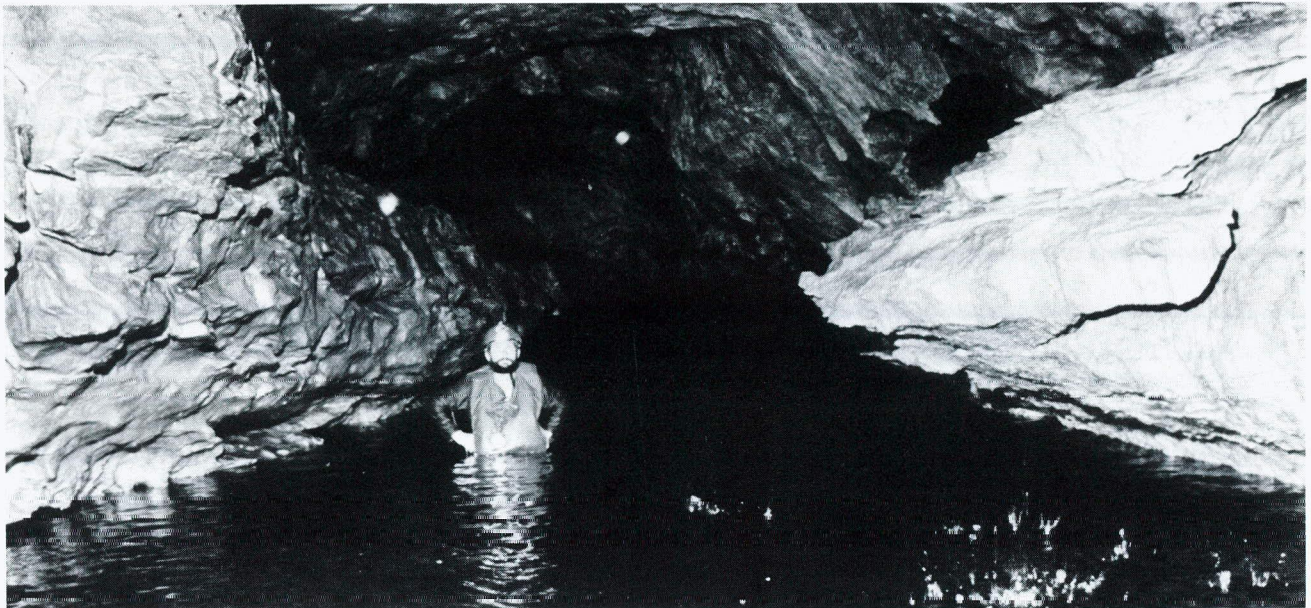
In the vastness of Deer Cave the river sweeps under an arch into its sump pool over 300 yards from the camera



Looking across the Melinau Paku valley from the northern portal of Green Cave



Searching for caves in Hidden Valley



Main passage in Deer Water Cave

LUBANG SUNGAI PAYAU — Deer Water Cave

Following the river up the Deer Cave valley leads not to Deer Cave itself but to a pile of boulders under the northern flank cliffs. Immediately over these, a wide arch leads back into the river, and the Deer Water Cave. There is a flood oxbow to the left but the rest of the cave's 2900 feet length is a simple conduit ending in a sump which the survey indicates is about 300 feet long to the sump pool in Deer Cave.

Structurally guided and generally uniform in section the passage offers easy walking, wading along the river. The normal flow is around 10 cusecs, but this increases vastly in flood. The only break in the passage is a section of deep water which requires swimming under the low arch of the Duck which normally has less than a foot of airspace. Just beyond it are some dry oxbows which are very close to the meander niches in the floor of the main Deer Cave, but no connection is possible.

LUBANG DARURAT — Mayday Cave

The strongly draughting fissure entrance to Mayday Cave is located at the foot of the cliff just south of the entrance to Deer Cave. Surveyed to a length of 2950 feet its passages are on three interconnected levels and it represents a truncated downstream extension of part of Deer Cave.



Entrance pitch in Mayday Cave

The 30 feet deep entrance rift leads straight into the wide, low-roofed Mud Room which extends as far as an enormous ascending boulder pile. At the top of this the collapsed floor of The Flat leads to more chokes, and even a branch passage fails to reach round this debris block. From The Flat, a mid-level passage with a floor of sand and boulders leads back past the Glory Hole, a beautiful clean shaft dropping into the roof of the Mud Room. A steep boulder climb continues above the hole to the airy views from the Balcony, 200 feet above the Mud Room. Roof level passages continue back to the northeast, but beyond some fine decorations, both end in calcited chokes, though the northern branch has a tiny impassable window into the Deer Cave valley.

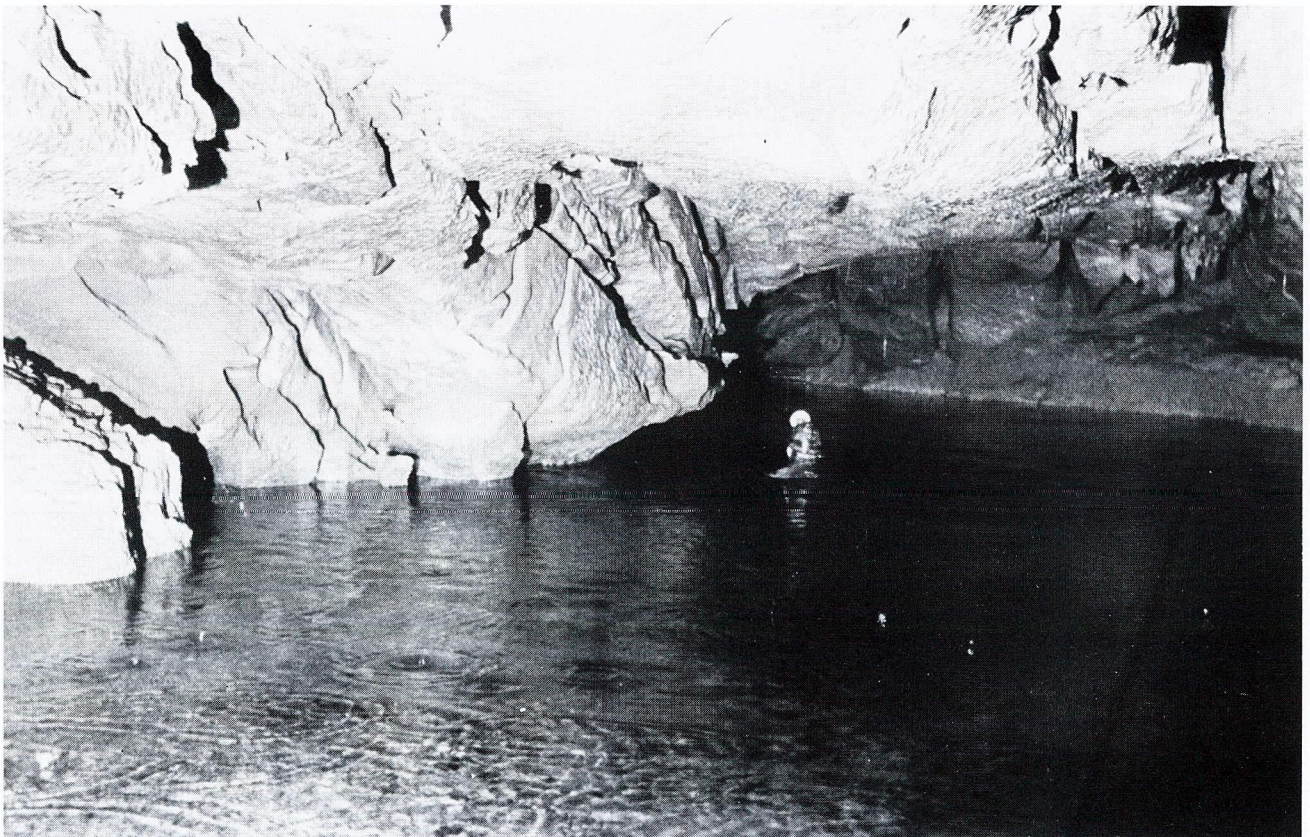
LUBANG ULAR — Snake Cave

The entrance is 200 yards north of Deer Cave in the Garden of Eden, and takes a small stream which drains a terrace above the level of the main river. The cave has an explored length of 3500 feet but was only surveyed to grade 2. Boulder chokes prevented a through trip to the presumed resurgence — a waterfall above the Melinau Paku.

From daylight, the stream may be followed to a choke and climb up into a roomy fossil cavern where the stream is regained by a corkscrew descent. Beyond a partial flowstone blockage the pleasant streamway narrows abruptly. Here a snake had to be removed before exploration could proceed. Downstream of this portal the way enlarges and a scramble over boulders passes through a chamber 150 feet wide and 200 feet long. To the right a fine tubular inlet passage ends in a choke beneath the floor of the large chamber. The stream now sinks into fissures under normal conditions and two levels may be followed forward to a tall cavern. At low level, crawls open into a watercourse where a sizeable stream sinks into boulders and can be followed up a sporting cascade in a fine vadose trench until the way is closed by further chokes. Back in the cavern a traverse at high level and an upwards rope climb give access to a series of passages terminated by avens or calcited boulder chokes and a 60 feet pitch drops into the watercourse below.

LUBANG HIJAU — Green Cave

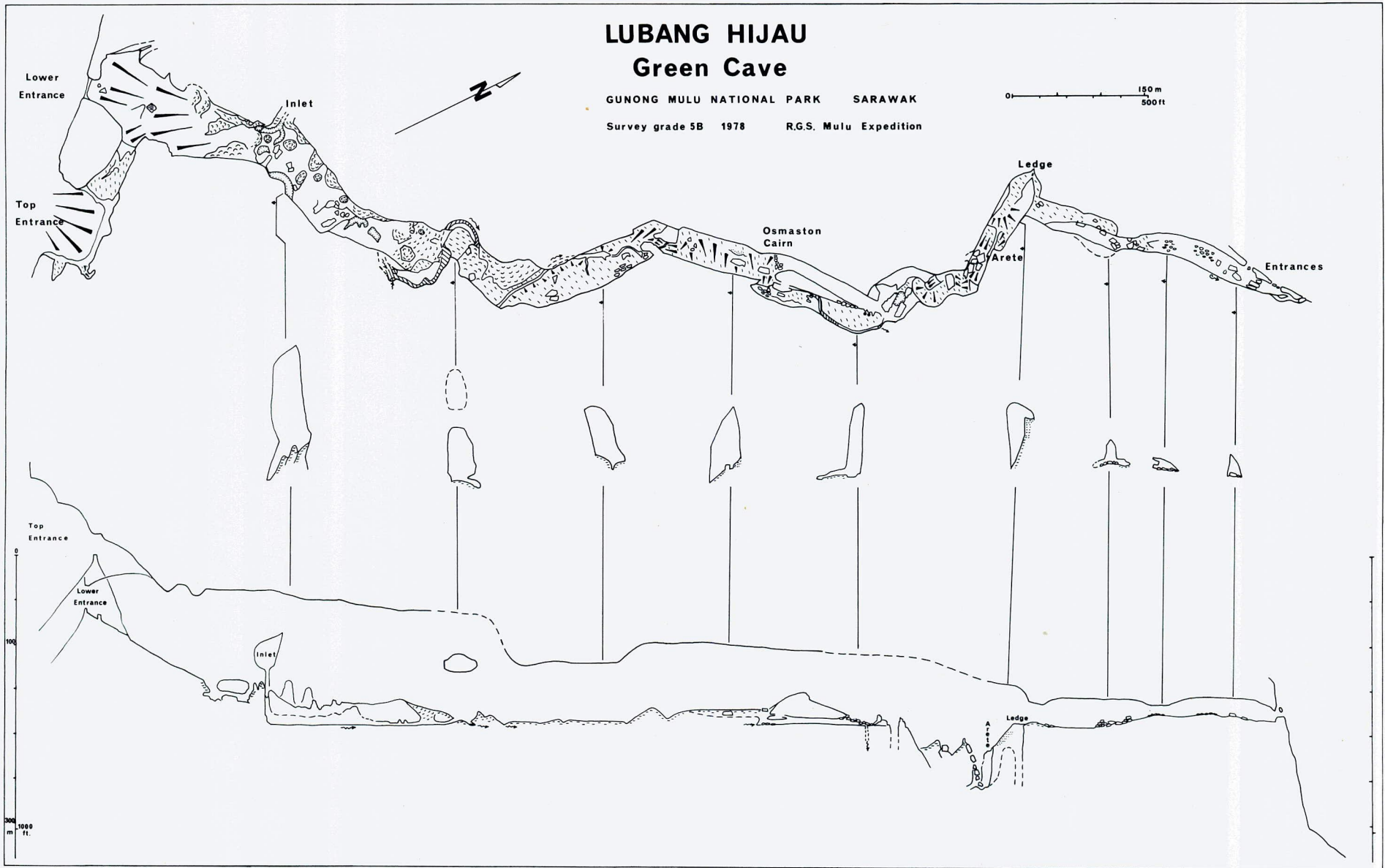
From the river entering Deer Cave the vast overhang above the top entrance of Green Cave can be seen high under the rim of the Garden of Eden. The cave is approached via a very steep path which climbs 500 feet and ends abruptly at a parapet overlooking the lower entrance. The explored length of the system is 9500 feet of which 7800 feet has been surveyed along the through trip.

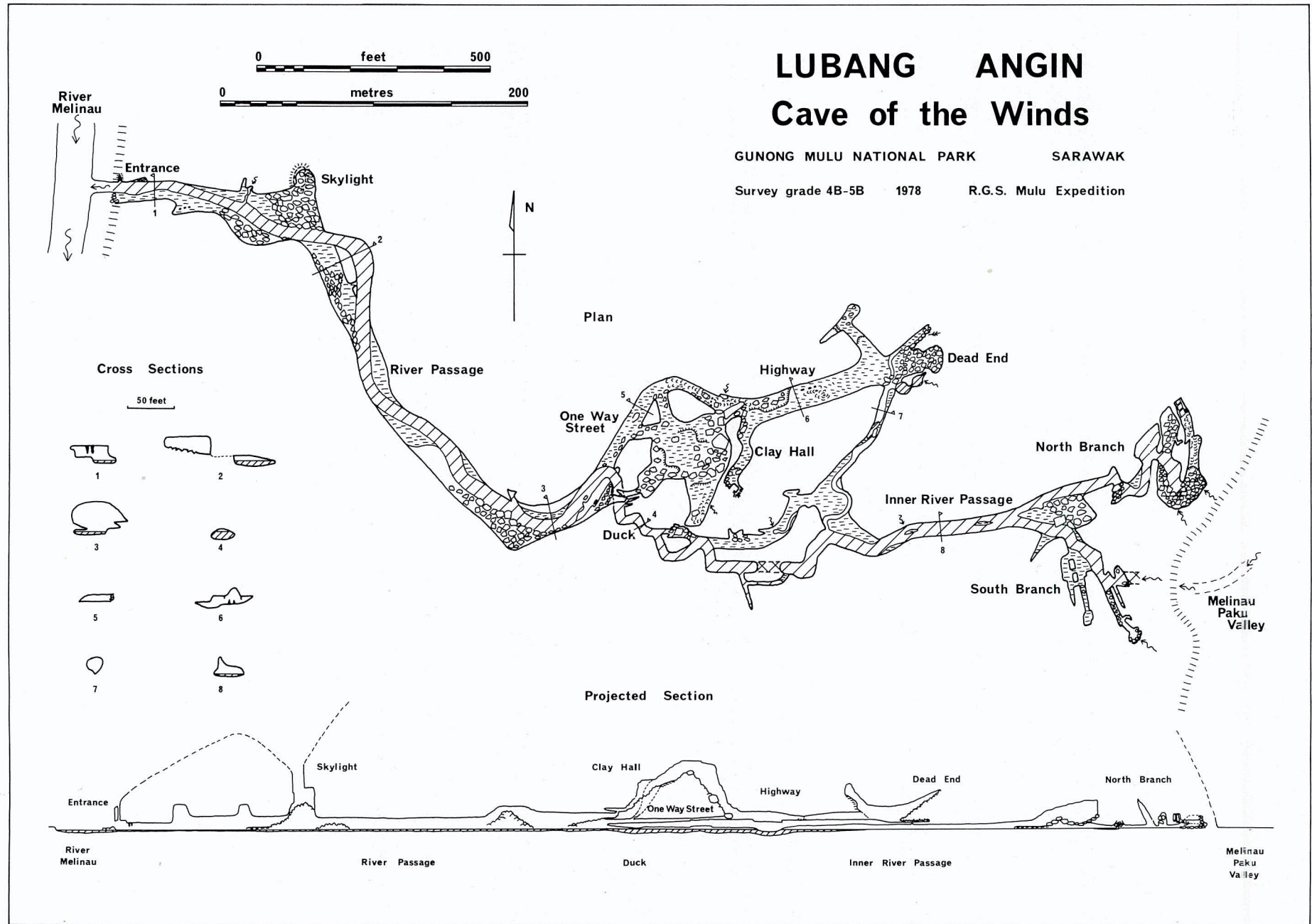


Approach to the Duck, in Cave of the Winds

LUBANG HIJAU Green Cave

GUNONG MULU NATIONAL PARK SARAWAK
Survey grade 5B 1978 R.G.S. Mulu Expedition





The parapet overlooks a vast entrance cavern more than 200 feet wide and twice that height. Partway down the cavern a second shaft of daylight streams down a steep ramp leading up to the top entrance. Below the ramp the cavern continues to descend and is floored by the stunted greenery which gave the cave its name. The passage levels out eventually at a deep floor trench which originates from an unexplored side passage. Progress along the continuing 300 feet high passage is by clambering over and round stalagmites 30 feet in diameter and crossing narrow bridges of fretted rock. A long slope leads down to a meandering stream undercutting the walls and the water can be traced back to the trench at the bottom of the entrance cavern. Downstream it sinks beneath a mountain of flowstone where daylight is last glimpsed from the entrance.

Beyond the flowstone the cave changes character as a normally dry trench is followed amongst dark banks of mud in a towering rift where the roof is lost in the gloom. Piles of dry guano cover sediments where slumping has revealed complex banding and faulting. This section ends at the Osmaston Cairn atop a large block where the route divides into high and low levels. The latter is easiest and a 20 feet climb rejoins the small stream just before it sinks into a small hole. The higher level is rejoined by veering left into a chamber populated by great towers of fretted rock guarding a deep pit. Avoiding the pit, the route onward is a rope climb of 70 feet to a scramble across a sloping ledge on to a col. Below this point a sump may be reached at a depth of 400 feet via a series of shafts.

From the col an ascent and involved descent down blocks ends abruptly at the base of a vertical wall of fill 70 feet high. The obstacle is overcome by a fortunate climb up a very exposed face (where a rope is a vital safeguard) and across a remarkable arête with 100 feet of vertical exposure on each hand. The arête merges with a steep slope, at the top of which is a 250 feet undescended pit across which a large passage beckons. It is reached via an incredible ledge which cuts across a blank wall and the roomy passage soon leads to daylight from a series of exits. The excitement is not over yet, however, since the way down to the Melinau Paku plain involves acrobatics on 150 feet of very steep vegetated cliff.

Green Cave is a vast fossil conduit and appears to be a continuation of the Deer Cave across the Garden of Eden. It contains some of the most spectacular underground scenery in Mulu – particularly the entrance with its staggering 600 feet of vertical range.

LUBANG ANGIN – Cave of the Winds

Situated almost at the southern tip of Gunong Api, Cave of the Winds has a well known and easily accessible entrance right on the bank of the Melinau River – a boat can be driven into the entrance. The cave has an explored length of 7500 feet, and through it flows a river with a normal flow of around 20 cusecs.



The roof tube of One Way Street overlooks the river passage in Cave of the Winds

From the entrance, River Passage is a comfortably large phreatic tunnel mostly about 50 feet high and wide. The river is mainly knee deep, though broad mud banks offer a drier alternative except where the river meanders across the passage and has cut into deep notches under the rock walls. There is a skylight shaft only a short way in, but, apart from that, River Passage is relatively uniform as far as a point 1500 feet from the entrance. Upstream of that point the river occupies a very aqueous series of tunnels, at first involving a low arch – the Duck – which must sump at times of high water. The Duck is only passed by swimming, and beyond it there is a choice of further swimming in deep canals, or a series of dry oxbows. These eventually unite to form Inner River Passage – where again there is comfortable walking in knee deep water, as far as where it splits into two. Each branch carries about half the water, but the southern one is little more than a series of joint guided rifts with the water emerging from a sump. North Branch is longer and larger but ends in a massive loose boulder choke, with a well decorated dry passage on the left. The end chokes of both branches are under the hillside dropping to the Melinau Paku valley where a branch river sinks only a hundred feet from the end of the cave.

A tributary stream into Inner River Passage leads up to a massive boulder choke, Dead End, which blocks the “upstream” continuation of the main cave. The Highway is a broad, decorated, tunnel with fine notched walls, but in what was the downstream direction it breaks into three. The south branch ends in a phreatic maze, and the middle route rises into the expanse of Clay Hall – floored with a combination of collapsed roof debris and semi-lithified clay beds. To the north, One Way Street loops round the edge of Clay Hall, and is so named from the unclimbable overhang at its end, which can be safely jumped down back into River Passage.

Besides providing a significant hydrological link between the Paku and Melinau valleys, Cave of the Winds contains some very attractive and easily accessible passages well worth visiting.

GUA AIR JERNIH — Clearwater Cave

Two hundred yards upstream of Cave of the Winds, the Melinau River is joined by a large flow of clear green water which emerges from a boulder pile. The main entrance to Clearwater Cave is 100 feet further up the hillside on the right, and behind it lies 16 miles of explored passages (15 miles surveyed.) A boulder slope leads down to the water, and just to the left is the resurgence chamber, fed by two river passages. The smaller carries the Goldwater, with a normal flow of around 50 cusecs, and the larger contains the Clearwater River itself which discharges 200 cusecs normally and a staggering 2000 cusecs in flood.



Main river passage in Clearwater Cave

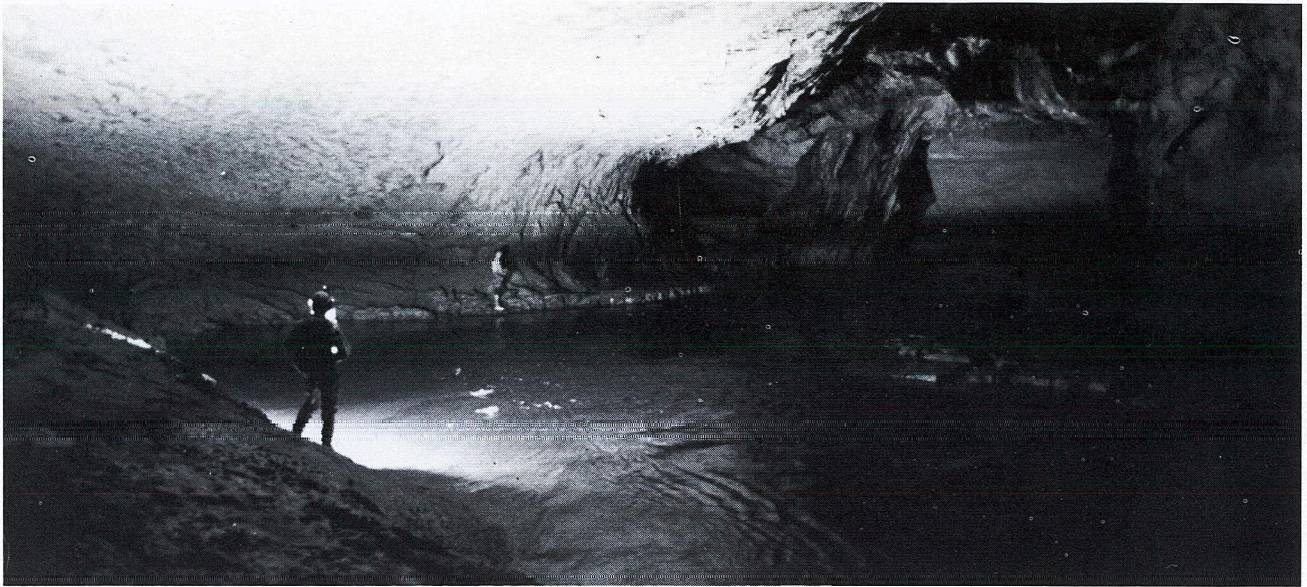


Main entrance of Clearwater Cave

The Water Passages

The Goldwater Series opens from the resurgence chamber as a broad river passage, but only a short distance upstream the river is constrained in a smaller canyon while a large fossil passage turns left to a series of chambers and an exit on to the alluvial plain. Upstream of the junction the main Goldwater Passage is a classic 30 feet tall keyhole passage, broken by a length where the canyon part of the section sumps while the upper tube leads through the base of a daylight shaft. The river can be traced another thousand feet to an upstream sump, but there are five inlets which can all be followed out to sinks on the alluvial plain, and in addition two branches of the older phreatic level also lead to daylight. A disconnected upstream continuation of the Goldwater Series contains a complex of oxbow canyons and keyhole passages. While the Goldwater River here flows in daylight on the edge of the alluvial plain, these passages include a fossil link through to the Clearwater River.

The main Clearwater River Passage extends to the right of the entrance slope, passing under a skylight 200 feet above the river, and here a high level passage appears to be a fossil resurgence. The river passage continues with impressive dimensions – averaging 100 feet high and wide for a mile. It also provides exciting caving since the powerful river has to be forded several times. Halfway along the river there is the intricate crossover to the Goldwater Series and a climb up to a roof passage which is obstructed by collapse pits in thick sediments.



Main river passage in Clearwater Cave

Eventually the magnificent river passage ends at River Junction where both branches soon sump but to the north dry passages lead to further sump pools and also steeply up dip to a high rift. To the south a route up through huge blocks enters the massive rift of the Battleship which rises to a loose boulder choke. Passing upwards through the choke one emerges in another vast cavern 200 feet wide and rising steeply to an aven. Down in an alcove to the left is a tortuous outlet, sprinkled with awkward climbs but remarkably, it suddenly meets another huge passage – Another Storey. To the north it ends dramatically 200 feet above the River Junction with a continuation tantalisingly visible across the gulf. To the south are three passages which all end in chokes.

The true way on is under the west wall of the Battleship in a maze of large muddy tunnels where the draught acts as a guide through to the river in Clearwater II just upstream of a sump. Wading up river for a quarter of a mile, progress is again stopped by a syphon, and the main river, which drains from Hidden Valley, is not encountered again in the known cave.



The junction at the head of the main river passage in Clearwater Cave



The dip of the limestone is clearly visible looking south along Inflation in Clearwater Cave

The Fossil System

Once more the way on is obscure, being up an offshoot immediately east of the entry point to Clearwater II. A hading passage runs south west for 300 feet, until a small roof opening, with a powerful draught, breaks out into a much larger fossil tunnel – Inflation Passage. This provides easy going for half a mile until a steep drop into Junction Cavern where further passages occur in the dipping bedding at both higher and lower levels. At three places the latter can be followed down to sumps which are at the same level as a tributary sump in Clearwater II. Inflation Passage itself continues to a choke and climb up into Detente Cavern which is 150 feet high and half as wide, but choked by stalagmited fill. Another exit from Detente is Camel Passage which rises steeply and then descends to a T junction with a giant fossil conduit – Revival.

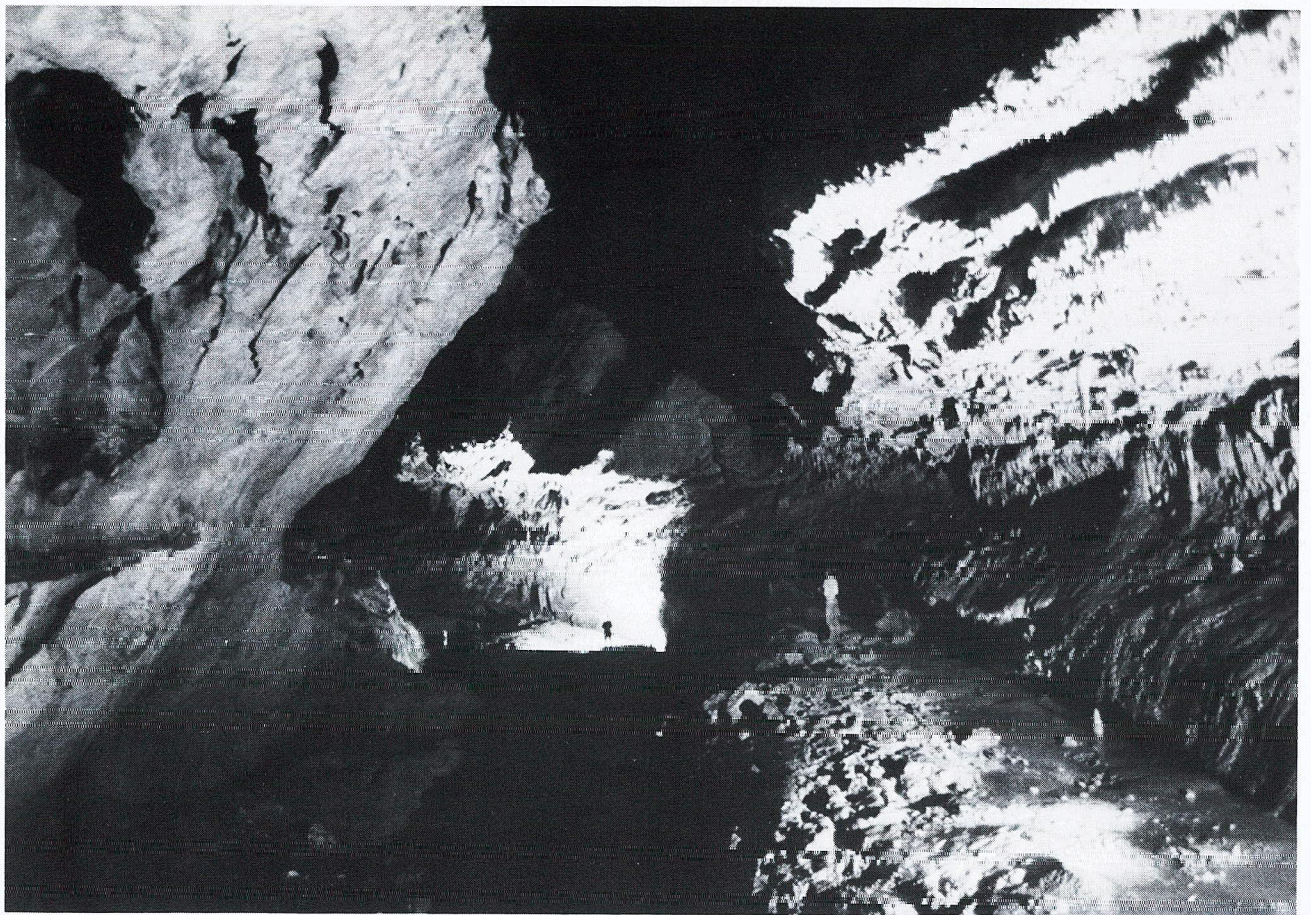
Back to the southwest Revival leads to the high level at Junction Cavern, but to the north it marches on with few obstacles for about two miles, with dimensions of 100 feet to 150 feet, wide and high. Only 500 feet along this highway is a large pit in the floor – the Volcano – which is easily skirted. Down the Volcano, a long boulder slope leads to a lower level phreatic tunnel parallel to Revival. Back to the south it descends to where it meets a stream and then sumps, but to the north it steadily climbs as far as a platform overlooking a steeply descending dip tube which will require a rope. Both this and four other branches remain unexplored.

Continuing along Revival there are two more proved connections with Volcano Series and then several unexplored pits, some of which involve spectacular traverses to bypass them. Eventually at Boulder Chamber the cavern swings sharply to the west and ends abruptly at a chasm – the Edge of the World. Other shafts also drop into a lower series and the proved height of the cave hereabouts is 350 feet.

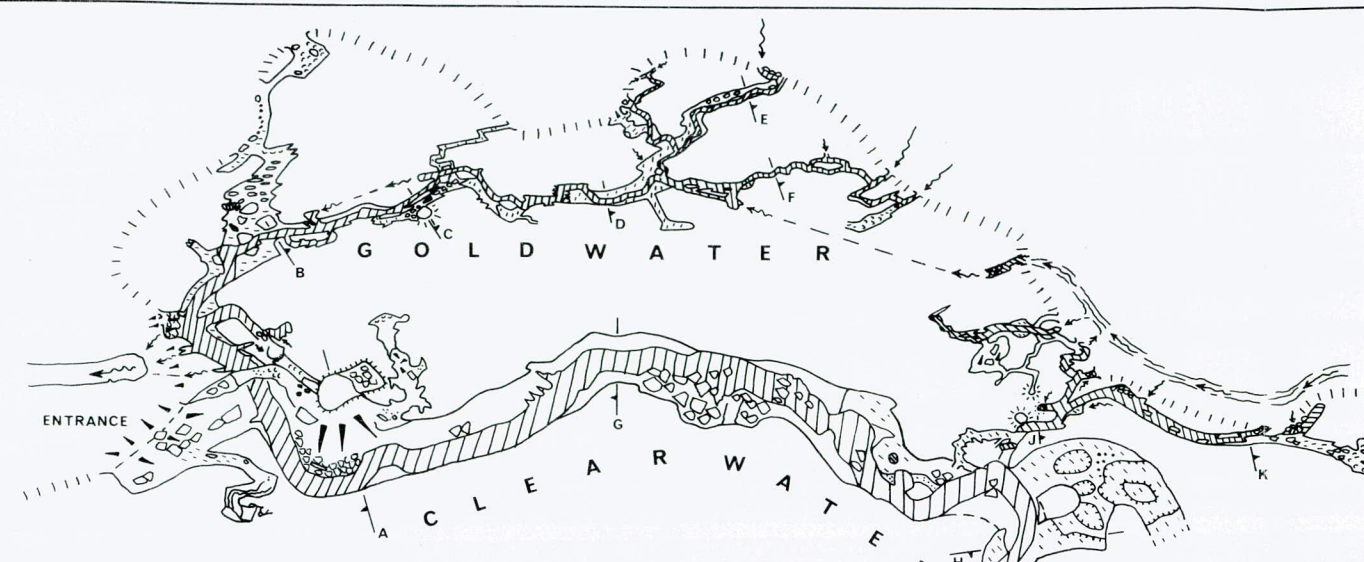
A 20 feet ladder at the Edge of the World allows a calcite slope to be gained and a large well decorated passage may be followed past numerous oxbows to daylight. Continuing down the calcite slopes for 70 feet is the way into the lower series. The obvious way on leads back under Revival in a similarly enormous passage. The size is however partly masked by enormous boulder piles rising to yawning avens which connect with the shafts in Revival. In addition other shafts drop to static water about 40 feet below. After 1000 feet of this boulder-strewn grandeur, the passage shrinks into a beautiful phreatic tunnel – Sheer Delight. Fifteen feet high and twice as wide, its floor has a broad shallow trench cut into banks of silt and sand. Further on there are some gentle switchbacks before deep shafts to water precede a terminal sump just beyond a hading aven to the overlying Dune Series.



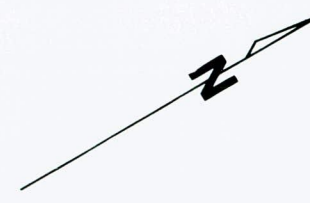
A convenient traverse round one of the deep holes in Revival, Clearwater Cave



Terraces and a small notch mark an old water level in Revival, the main fossil tunnel in Clearwater Cave

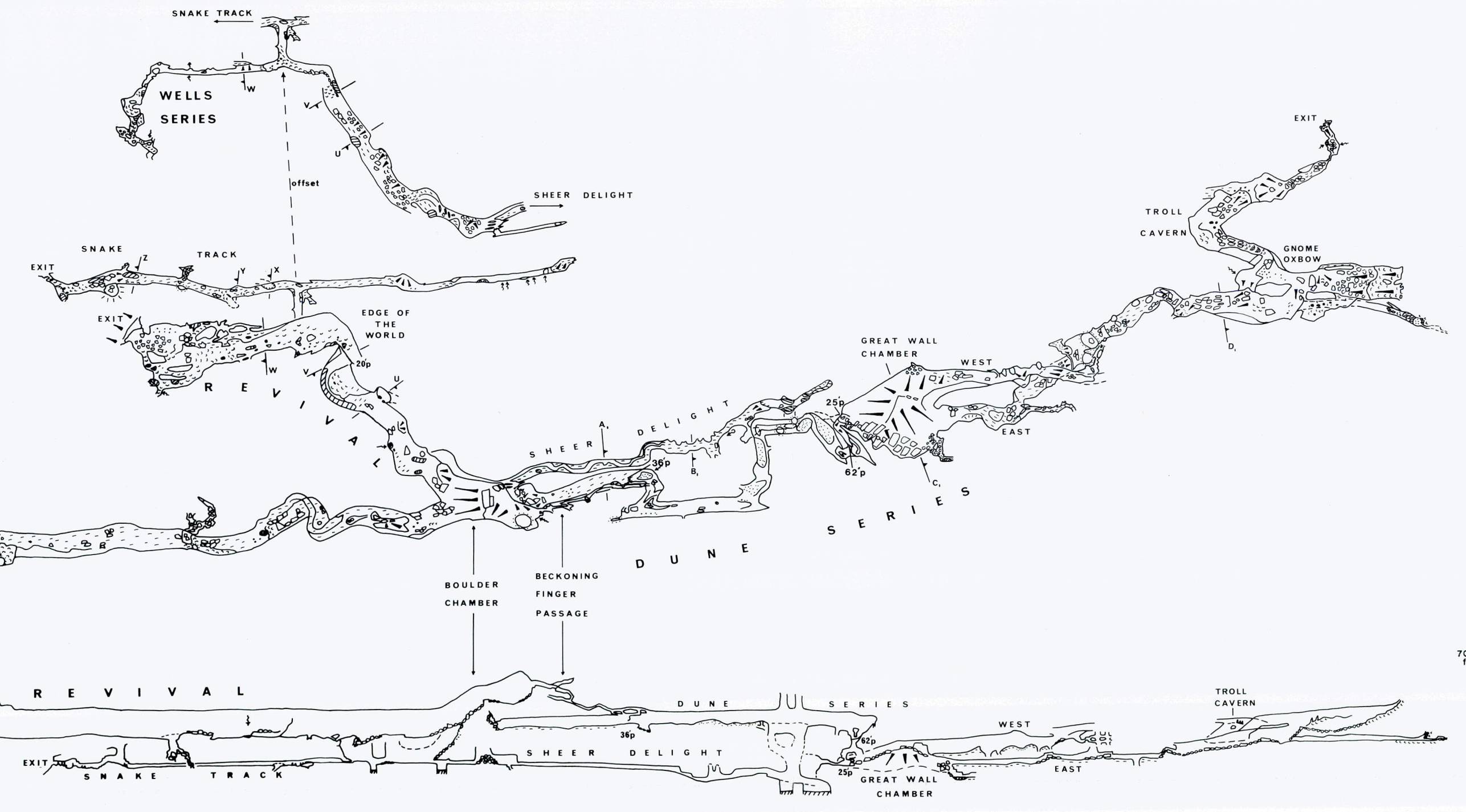
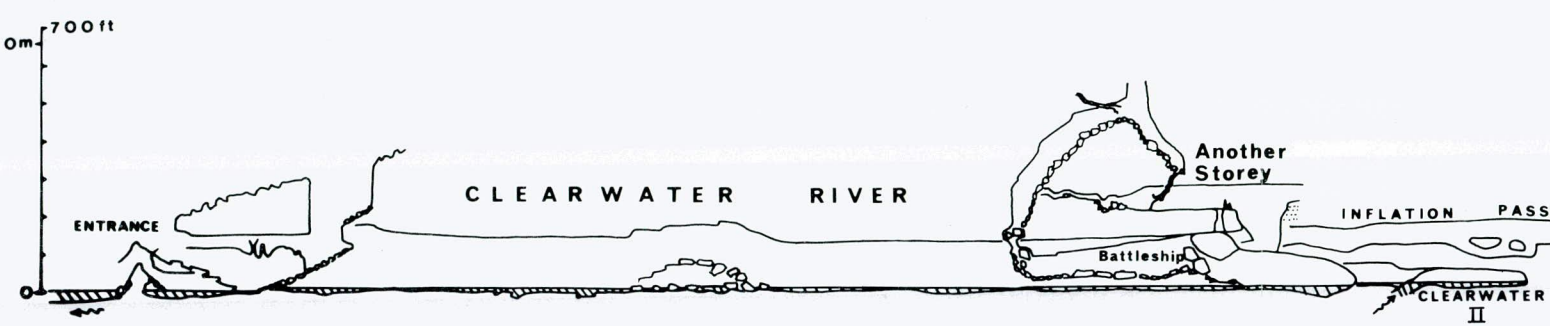
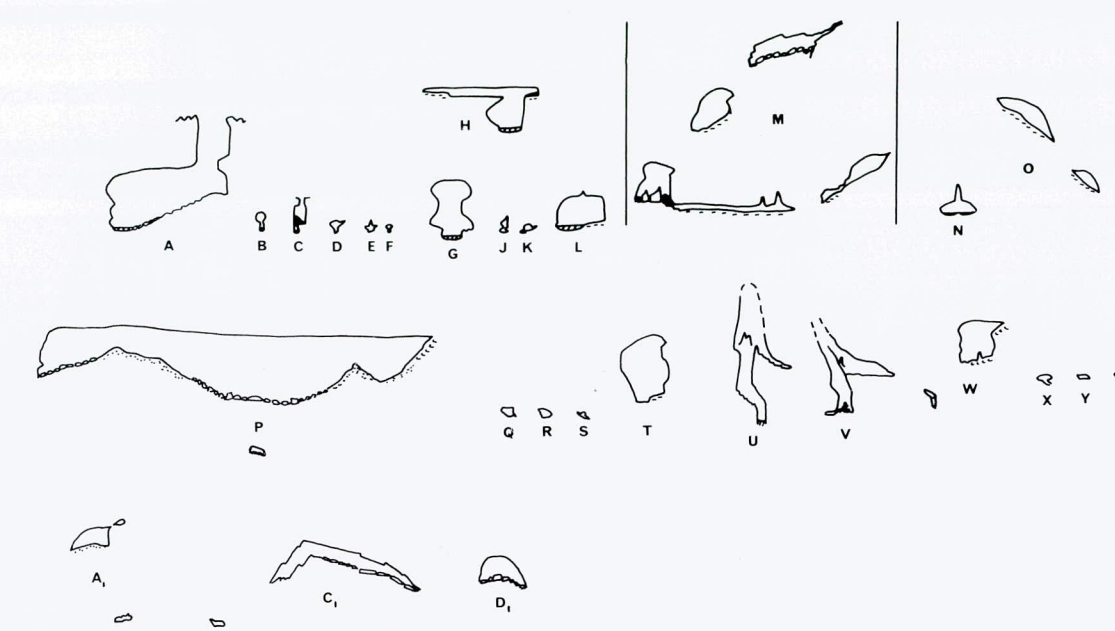


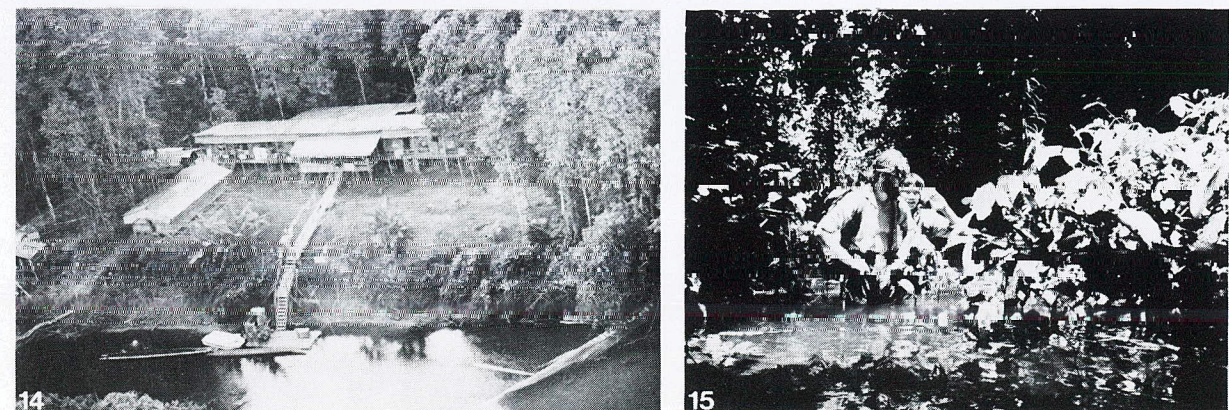
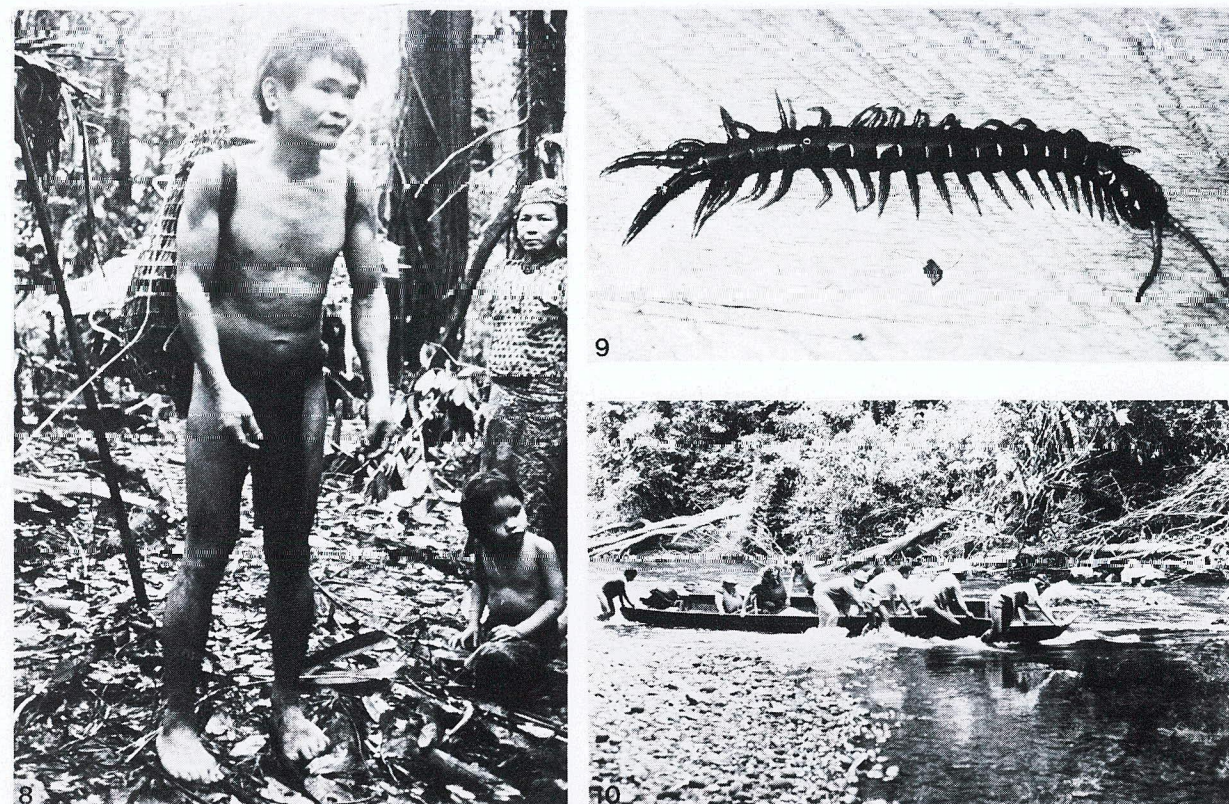
Survey grade 5B 1978
RGS Mulu Expedition



GUA AIR JERNIH Clearwater Cave

GUNONG MULU NATIONAL PARK SARAWAK





Looking up the 450 feet deep entrance pitch of Solo

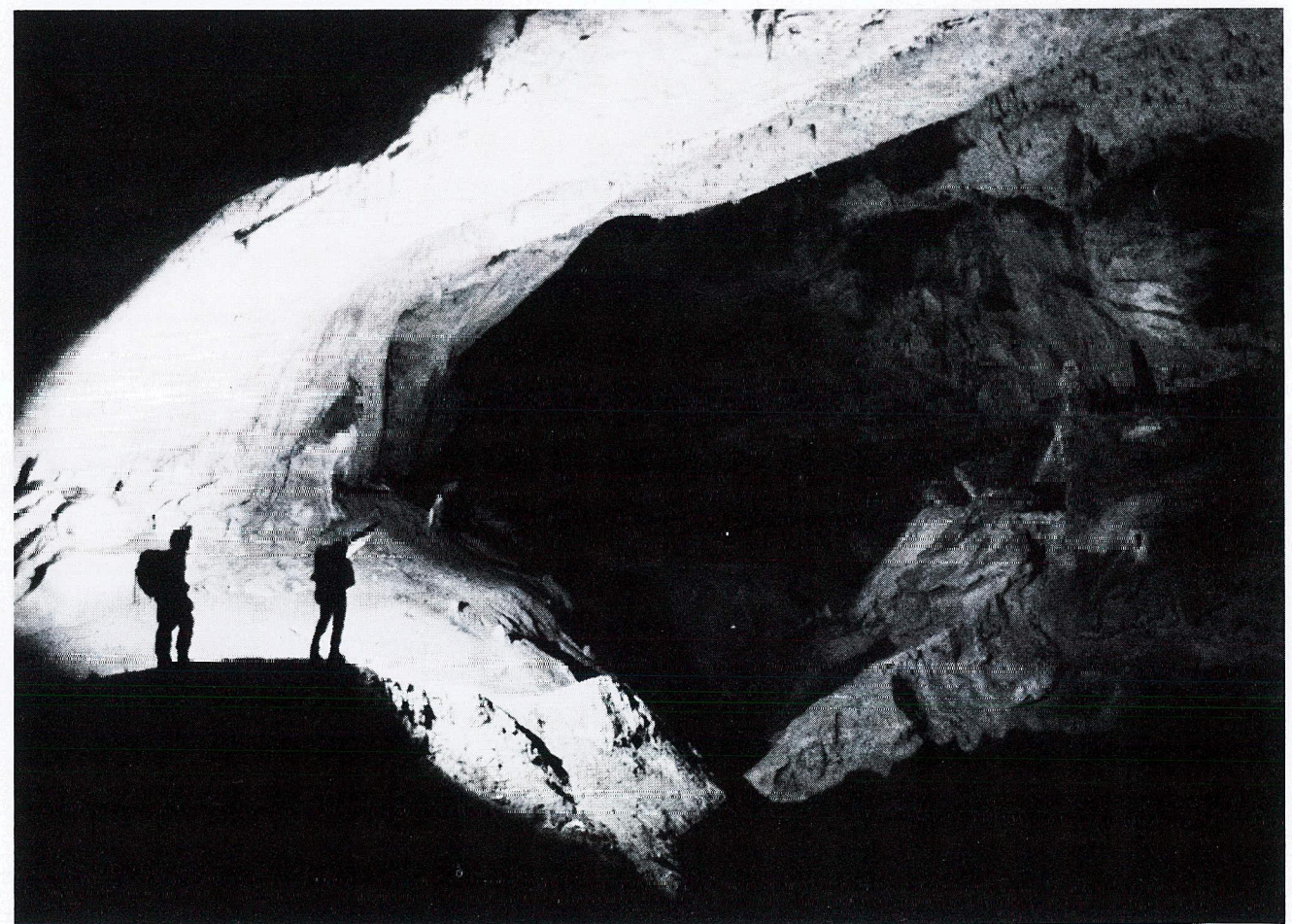
Beneath the calcite slope a stooping passage enlarges quickly at a junction where the intricate Wells Series continues south via some involved climbs to an undescended pitch. Along the main route a T-junction is soon encountered where the right branch is easy going for 1200 feet to a mud choked sump in a deep, dark chamber. The left passage is the Snake Track, so called because of the remarkable narrow polished tracks seen along its length. The passage provides a splendid route out to the surface just above the Goldwater River.

Back at the top of Boulder Chamber a rather obscure route leads to Beckoning Finger Passage. A succession of rather muddy climbs ends at a 35 feet pitch into a large tunnel — the breakthrough into Dune Series. Back to the south is a choke beneath Boulder Chamber, but north is a traverse amongst stalagmites to more formations and a pool which is the last water for the next mile. The tunnel is floored by sand dunes until cautious progress past two deep shafts leads to a couple of rope climbs and a 60 feet pitch. The descending trend is continued by another rope climb and a remarkable slot which is a pitch into the roof of a wide chamber.

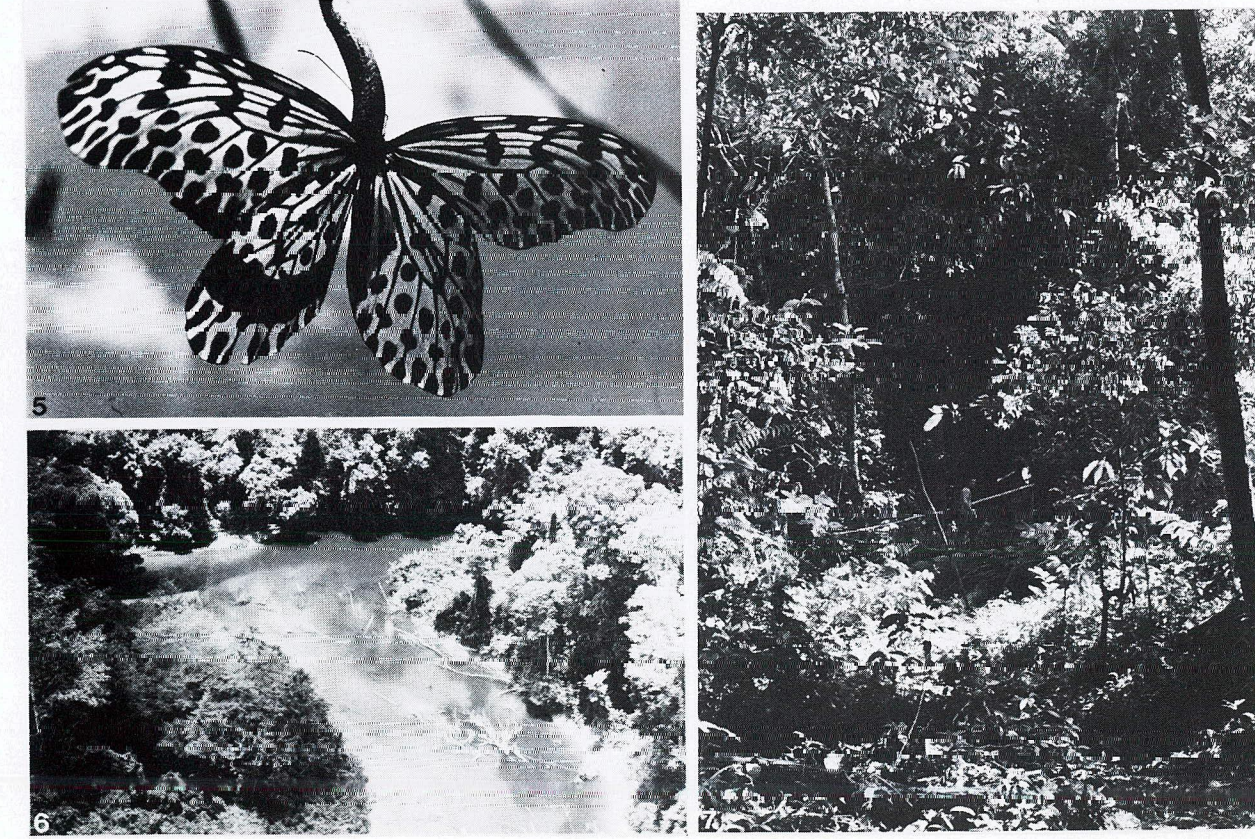
This marks the end of the long descent and the way now opens into the wide expanse of Great Wall Chamber which is floored by shattered blocks and slabby scree. There are two exits. Down on the left a high rift is pitted by shafts which hinder progress and swallow up tackle, so exploration is incomplete. A slope to the right leads to a more straightforward passage over piles of breakdown into yet another vast cavern. A higher level on the same giant scale is populated by hunched stalagmites (hence Gnome Oxbow) but eventually it is terminated by a calcited boulder pile. The lower level may be followed further by crawling over calcite but it is finally obstructed by formations.

Back in Gnome Oxbow a valley in the floor provides a way into a towering canyon which opens into Troll Cavern. Here more underground mountaineering and a short crawl lead to a larger section and a boulder choke where digging was required to force an exit to daylight.

The Clearwater System is by far the longest cave yet explored at Mulu, and with eight open passages and numerous pits left to be investigated in the known cave its final length could be prodigious. Throughout the cave the passages are enormous even by world standards, and it is considered that the Melinau River must have played a part in the development of the giant strike passages.



In the heart of Clearwater Cave, deep holes break the floor of Revival just before the Edge of the World

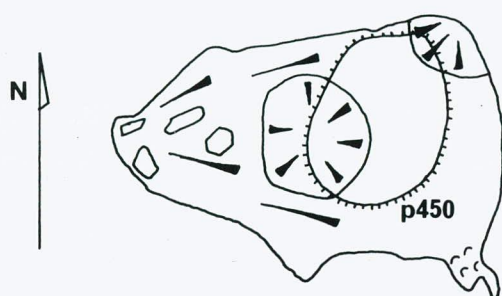


1. Penan fisherman
2. Insect-eating pitcher plant
3. Photographer at work
4. Crossing the Melinau Paku
5. Forest butterfly — the common tree nymph
6. The Melinau from the air
7. Forest
8. Nomadic Penan hunter
9. The dreaded centipede
10. Longboat hauling on Melinau rapids
11. Eight-eyed spider
12. Climbing in Deer Cave
13. Captive lizard
14. RGS base camp at Long Pala
15. In the alluvial forest

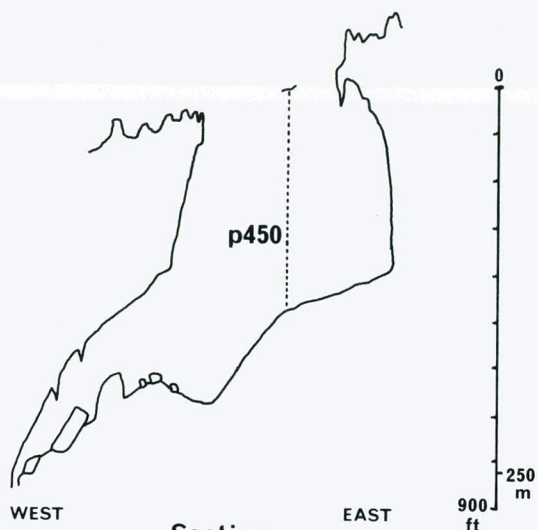
SENDIRIAN Solo

GUNONG MULU NATIONAL PARK SARAWAK

Survey grade 3 1978 RGS Mulu Expedition



Plan

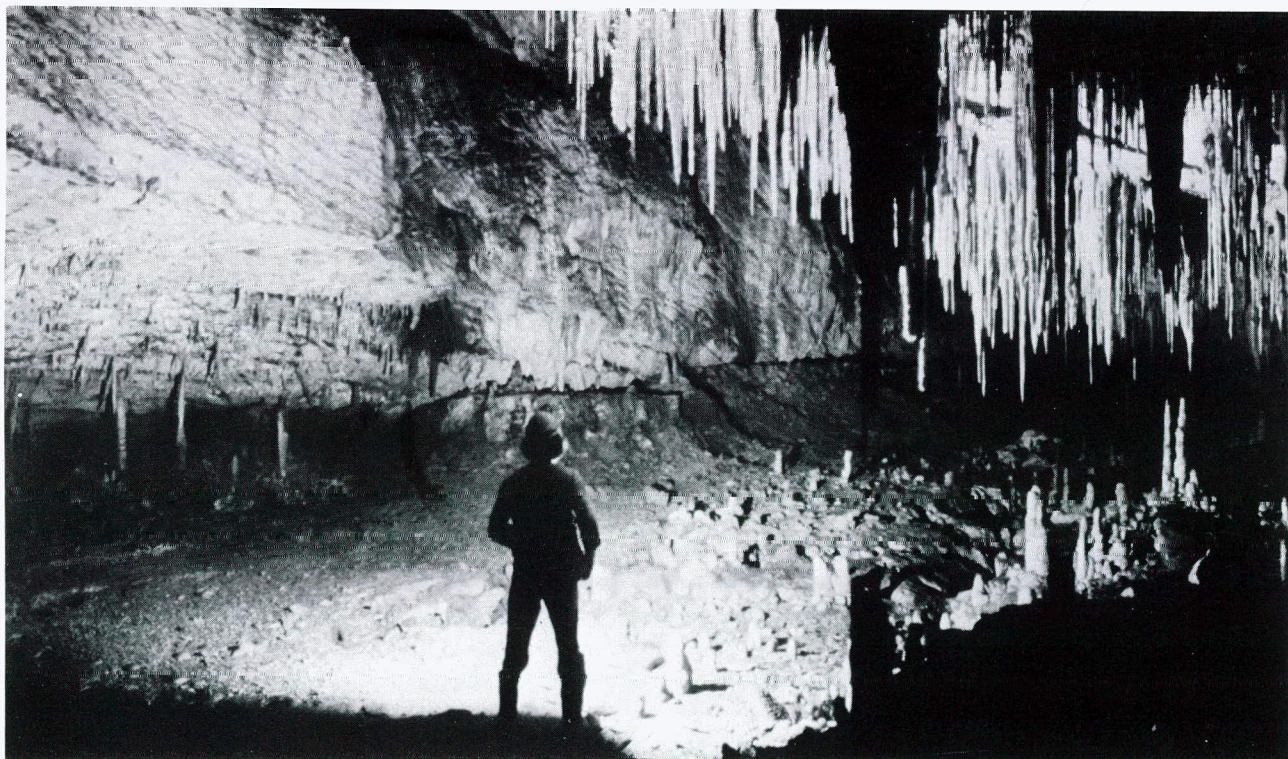


Section

SENDIRIAN – Solo

Not far north of the Snake Track entrance to Clearwater Cave, a cut path climbs 1800 feet on to the limestone plateau of Api and then northeast to the gaping shaft of Solo. This impressive pothole is the only one so far descended in the Mulu Park, and it has been explored to a depth of 850 feet.

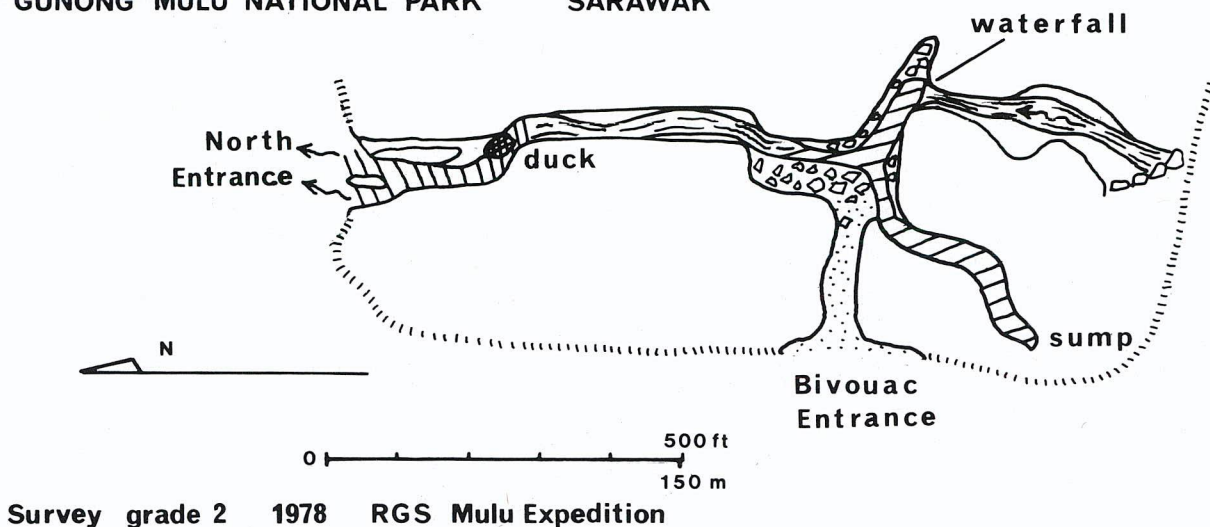
From the southern rim, a free hanging pitch of 450 feet lands in unstable 30 feet tall trees. The walls overhang all the way round, and the floor slopes steeply down to the northwest, ending in a small inward-draughting hole behind a large boulder. This leads immediately to a short, undescended pitch. A series of small chambers, one floored with gour pools, opens off the southeast side of the shaft. The only way on is down the short pitch, and as this is almost directly above some large avens in Clearwater Cave, 500 feet below, there are excellent prospects of a very spectacular connection and a classic through-trip cave system.



Stalactites and stalagmites adorn the main tunnel of Dunes Series in Clearwater Cave

GUA HARIMAU Tiger Cave

GUNONG MULU NATIONAL PARK SARAWAK



GUA HARIMAU – Tiger Cave

A conspicuous feature at the northern end of the Melinau Paku valley is a large hole in the limestone wall of a spur projecting from Gunong Api. The hole is unapproachable without a serious climbing project, but beneath it, on the bank of the river, is the entrance to Tiger Cave, containing nearly a mile of explored passage.

From the river bank entrance a low shingle-floored passage leads into a wide chamber with a large stream crossing the far side. Branch passages lead to an upper series and also a high-level entrance overlooking the Melinau Paku. The cave stream can be followed up a ten feet high waterfall to a fine roomy stream passage, and it ends in a choke of boulders and rotting timber which must be very close to the river bed upstream of the main entrance. Downstream from the entrance chamber, the streamway sidesteps abruptly and then continues in a tall northbound rift passage along an inclined fault or joint. After about 400 feet on this one fracture, the water cuts into a low undercut on the left with about a foot of airspace. This leads directly to a low resurgence exit, from where the water flows northwest to rejoin the Melinau Paku.

The main active part of Tiger Cave forms an oxbow to the Melinau Paku river, and it is a very pleasant segment of cave. Its many small inlets are just some indication of the much more extensive system of caves which must exist in this area.



Main river passage in Tiger Cave

LUBANG RAMALAN – Prediction Cave

Examination of air photographs before leaving for Borneo identified a great overhang in the south wall of Hidden Valley as a likely fossil sink for the river which usually goes underground close by. The total surveyed length of the system explored is 2000 feet, but the true length is in excess of this, due to numerous alternative routes along infilled passages. The trend of the cave is south west along the Deer Cave-Green Cave line and it must once have carried the Lost River of Hidden Valley through the mountain to the Melinau Paku.

A steep slippery slope funnels down into the entrance and the roof lowers to three feet before leading out into a chamber where roof drips soak away into a shingle choke. A crawl to the left, however, rises up into a huge echoing aven chamber over 200 feet high and wide, in which great thicknesses of pebbles and clay are exposed. Again, the improbably way forward is a crawl into what must be one of the most ridiculous passages under the earth. It is about 300 feet wide, mostly two or three feet high, and very confusing.

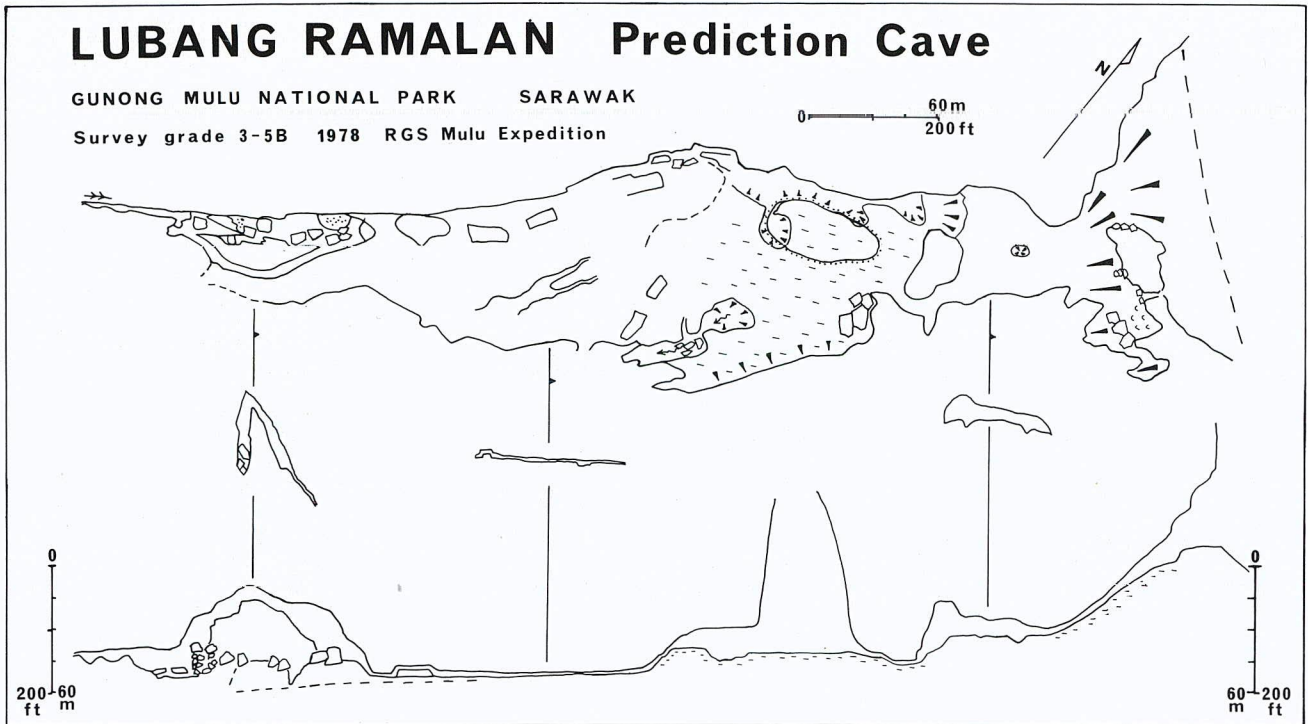


The great stalagmite named the Watchman in Wonder Cave

LUBANG RAMALAN Prediction Cave

GUNONG MULU NATIONAL PARK SARAWAK

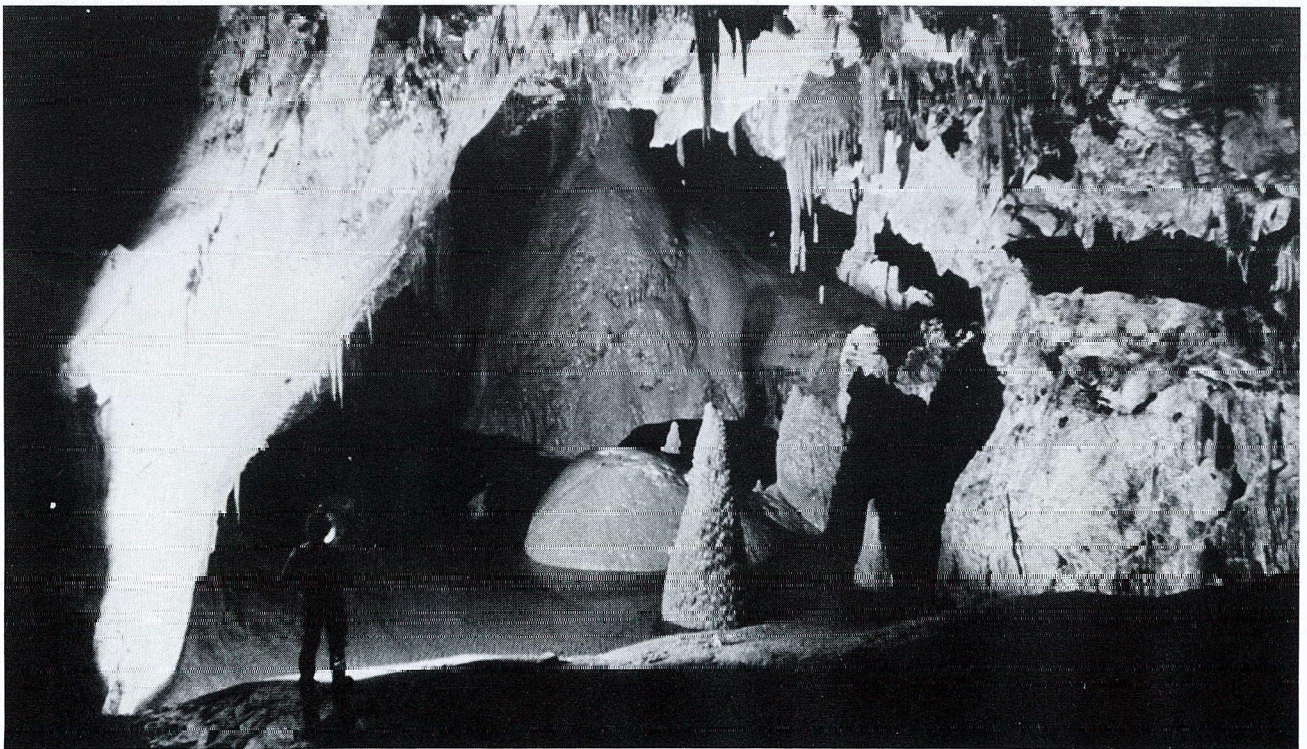
Survey grade 3-5B 1978 RGS Mulu Expedition



By keeping right a way opens up on to a great arête of fallen rock 80 feet high. A remarkable flat "road" runs along the left of the arête, but all ways down are blocked. Right of the arête a scramble amongst shattered boulders leads to a short pitch into a chamber full of boulders and ancient sediments. The only exit known is along a rift and through a very tight squeeze to calcited boulders blowing a powerful draught.

GUA AJAIB – Wonder Cave

This remarkable cave system is located 320 feet above and almost north east of the camp site in Hidden Valley. It has an obscure entrance, but the powerful draught blowing from the small opening gives some indication of the extent of the system. Very nearly three miles of passages have been surveyed in the cave.



Moulin Rouge passage in Wonder Cave



Delicate pointed helictites in Easter Grotto, Wonder Cave

From the entry an easy old phreatic passage ends at a 90 feet deep pit across which lies a spacious cavern. The passage at the bottom of the pit soon chokes, but another only 15 feet below the lip leads to an undesended drop. A bold step across the pit enters the chamber beyond and an opening to the left is the start of 500 feet of passage, notable for fine calcite crystals, but ending in a pitch to a choked fissure. Straight ahead past ancient formations the chamber descends to a loose climb and a 25 feet drop, where a rope is a vital safeguard. Further intricate climbs and a squeeze lead to another short rope drop, below which the way lowers to the Roaring Forties – a crawl in mud and water accompanied by a draught of 25 mph. More interesting climbing follows until the passage side-steps, and joins a similar rift which is unexplored.



Gypsum flowers on the wall of Wonder Cave

The passage now changes both its trend and character. It widens to a 20 feet diameter tube encrusted with gypsum and rises steeply in the next 600 feet to the base of a giant slab. A rather improbable climb up to the right (the Passover) suddenly emerges in a vast tunnel 150 feet wide. Straight ahead are fine gypsum trees, but the passage chokes. Back to the left, however, the tunnel continues to the Watchman – a splendid 30 feet high stalagmite and ahead, a long cavern plunges down a calcite slope only to end in a small pool. The way forward is up a slope behind stalagmites, and then an exposed route up a vertical cliff of fill. More formations are heralded by the Sentinel, a long finger 20 feet tall, before the floor drops into the great void of Calgary where three towering stalagmites glitter with crystals. The floor is covered in a mat of similar crystals and this fairyland continues 150 feet high and wide for 500 feet to a wall of calcite which chokes the passage. A small hole in the wall opens into Easter Grotto which is plastered with enormous white helictites growing from orange stalagmites. Down a short pitch is the Sepulchre and an even finer display, but there is no way forward.

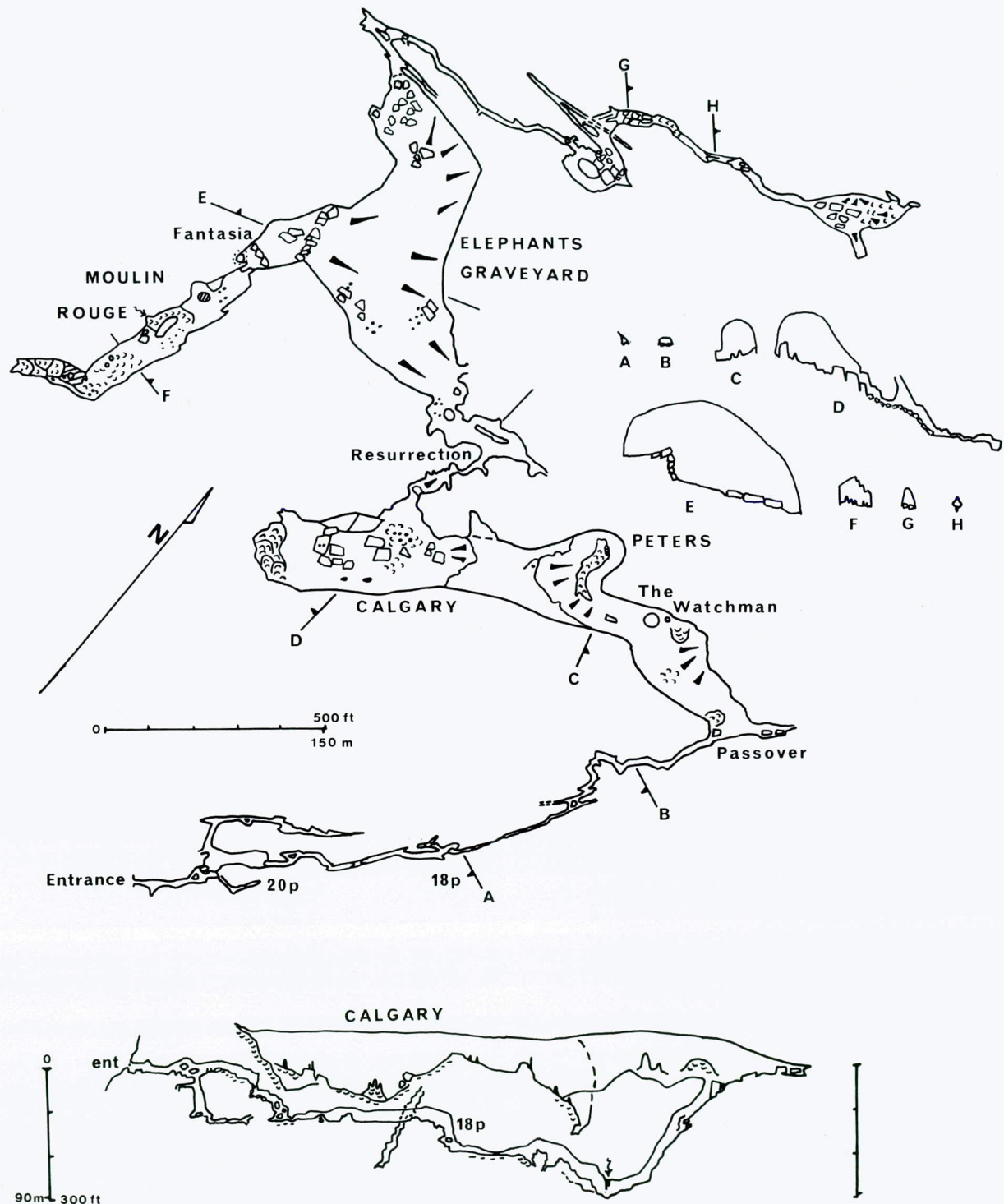


Helictites on the wall of the Moulin Rouge, Wonder Cave

GUA AJAIB Wonder Cave

GUNONG MULU NATIONAL PARK SARAWAK

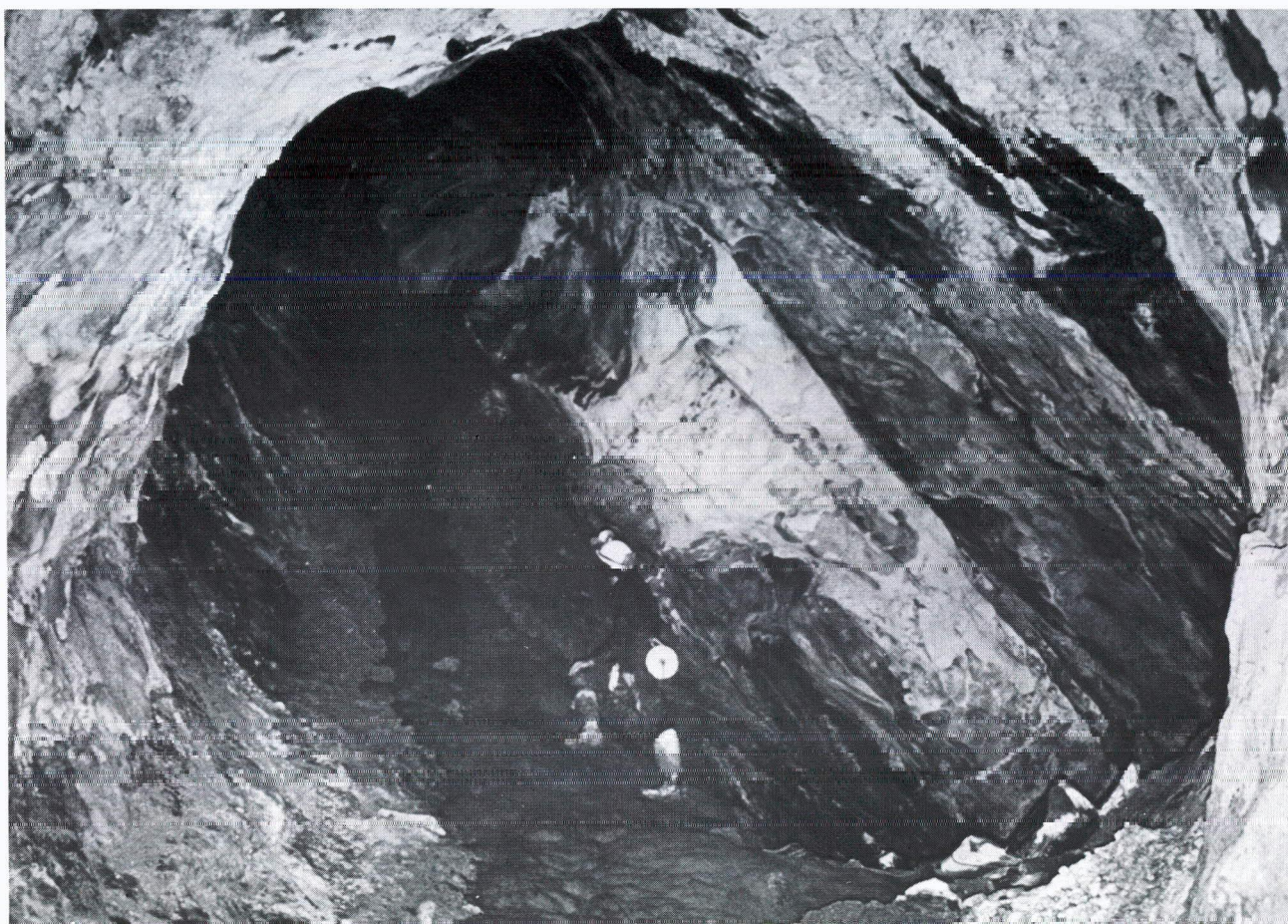
Survey grade 5B 1978 RGS Mulu Expedition



In the lowest depths of Calgary a slope plummets into a tall chamber where the only exit is a flat out muddy crawl with a powerful draught – Resurrection. The agony only lasts 100 feet before a rapid enlargement occurs, and the roof soars into blackness at the start of the Elephants' Graveyard – the largest cavern yet known in Gunong Api. The L-shaped cavity has a vertical range of 350 feet and is 1000 feet long and 300 feet wide. From the highest point above a vertical boulder wall, the wonderland of Moulin Rouge trends south. It begins with a display of huge calcite fans where great care is needed to avoid their destruction. Along the succeeding passage the display of stalagmites, stalactites, crystals, coral and helictites is dazzling, and culminates in a cave lake where stalagmites form islands. The final choke of flowstone is surrounded by helictites – some of which are three feet long.

At the northern end of the Elephants' Graveyard a low arch is almost obscured by breakdown, but it carries the siren draught which guided exploration thus far. A pitch can be bypassed by a low crawl and the tall passage breaks out into a high fault chamber. Passages exist at several levels in the fault, but all eventually choke and the only way forward is down a circuitous climb into a large, undulating tube terminating in a wide cavern. No possible exit was found, and the draught comes down an aven which will require bolting.

Wonder Cave is considered to have the greatest variety of underground decoration yet discovered. Many of the examples are unique or outstanding, and the difficult access should ensure their preservation for future generations. The profusion of the decoration is related to the great age of the system, whose phreatic passages are now perched 400 feet above the floor of Hidden Valley and 1800 feet above the present resurgence levels.



One of the inclined phreatic tubes in the Ramps, Tiger Foot Cave

LUBANG RENDAH HARIMAU — Tiger Foot Cave

The vertical 2000 feet high cliffs forming the north wall of the Melinau Gorge are broken by a number of cave entrances, the largest of which is known locally as Lubang Harimau – Tiger Cave. Reaching it from the outside poses something of a problem as it is well over 1000 feet up. The only explored cave is Tiger Foot Cave, entered from ledges just above the forest-covered scree pile at the foot of the cliffs. With nearly 4500 feet of mainly fossil passages it reaches a depth of 420 feet at a sump which must be close to the level of the Melinau River.

From the Main Entrance, the Old Cave leads to Boulder Hall where a hole in the floor drops into some roomy phreatic tubes and a descending keyhole passage. This loops under the entrance passage and then a steep flowstone slope leads up to the Lower Entrance which is only a body sized hole. Hidden behind a stalagmite a small draughting tube leads to the back of the cave, via Agony Pitch, an uncomfortable descent and an excavated ascent through a fine false floor. Spiral Chamber is 150 feet high and 50 feet in diameter but a spiralling route allows the 100 feet descent to the floor to be made with the use of only a few feet of handline. The passage out at the bottom is very well decorated with stalactites, cave coral, and the calcite fan splash deposits. Behind a bank of fans a heavy drip can be followed into a series of rifts where more water descends from the roof. Spiral Series is a complex of bedding guided rifts inclined at about 45°, small phreatic tubes and vertical joint guided shafts which can be followed to a narrow rift which absorbs most of the water, and a mud choke at the lowest point.

The main part of the cave continues north east from Spiral Chamber as a magnificent fossil phreatic series. The main conduit is Benarat Walk – a horizontal tube at least ten feet in diameter which varies in size due to both varying amounts of fill, and also unexplained changes in the size of the original bore. It closely follows the bedding in the limestone, and its branches and changes in direction are accordingly inclined with the dip of 45-50°. The terminal sump is in a sediment choked area where the main tube turns west, and above it to the east are the rising tunnels of The Ramps. The first few of these are just climbable, though ropes are needed for the descents, but Way-On Aven, a beautiful ten feet diameter tube rises so steeply that extensive protection will be needed for its eventual ascent. The cool breeze coming down the aven suggests a possible link with Tiger Cave many hundreds of feet above, and provides a tempting exploration for the future.

Even though it represents only a tiny fraction of the phreatic caves in Gunong Benarat which were fossilised by the incision of the Melinau Gorge, Tiger Foot Cave already contains some very pleasant passages and formations.



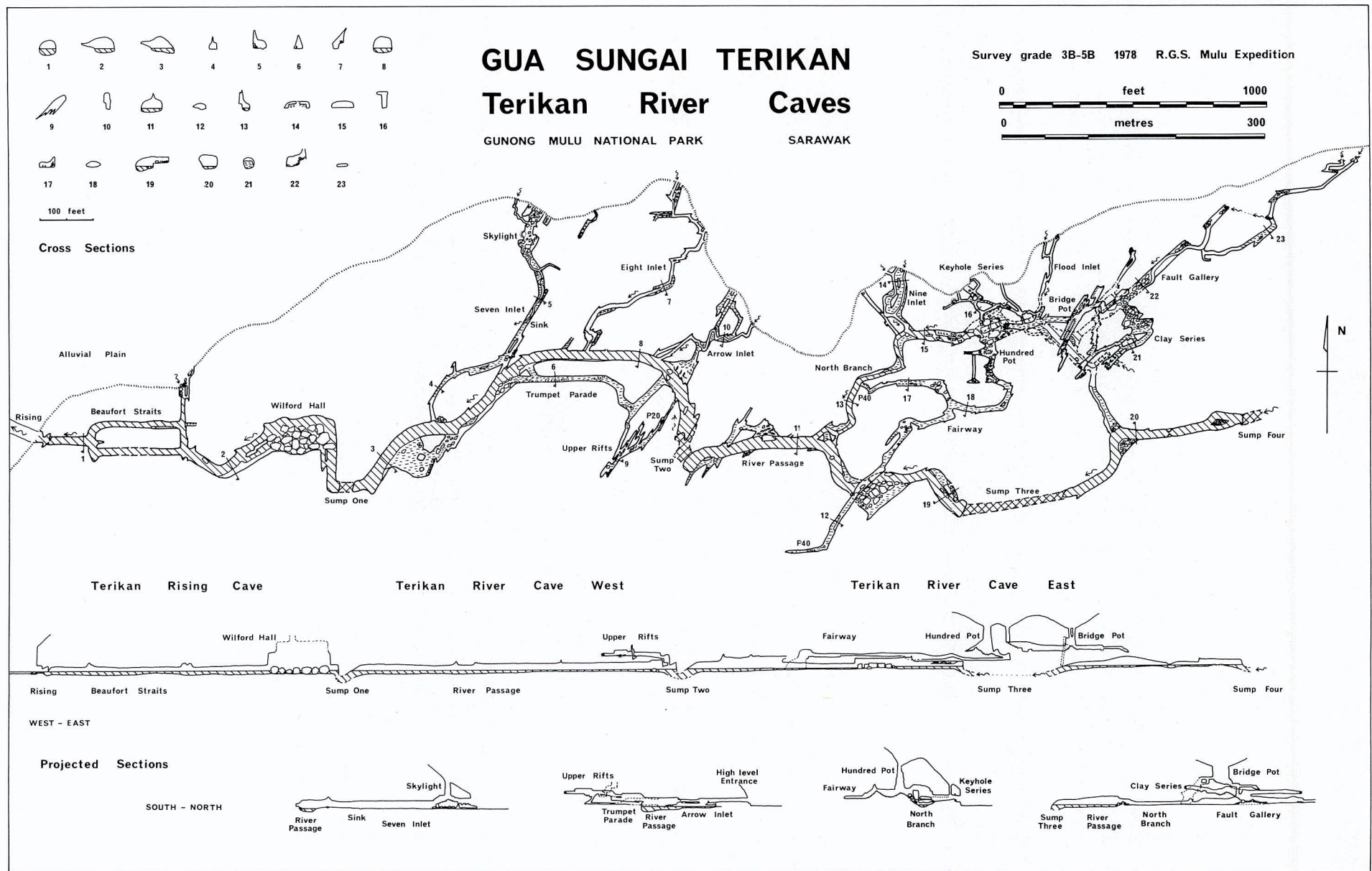
Benarat Walk in Tiger Foot Cave

GUA SUNGAI TERIKAN – Terikan River Caves

The River Terikan rises from the north west corner of Gunong Benarat and appears to be the only major drainage channel from the whole limestone mountain. Behind the rising lies over four miles of explored cave, with more than a dozen entrances from the alluvial plane to the north. Through these caves the Terikan River, with a normal flow of about 100 cusecs, can be followed for well over a mile, through exploration is interrupted by a series of sumps.



Flowstone nearly blocks the phreatic tunnel of Fairway in Terikan River Cave East



A low narrow arch at the back of the resurgence pool leads straight into the Terikan Rising Cave. Once inside the visitor must be prepared for a long swim, as the passages are large and gloomy canals, with vertical walls dropping straight into deep water. An oxbow system and a branch to daylight converge upstream in a single tunnel, 40 feet wide and 25 feet clear above the water surface, carrying the entire flow of the river. Beyond the soaring roof and gigantic guano-spattered boulders of Wilford Hall another short canal leads to an impassable sump.

Sump One separates the Rising Cave from the West Cave, in which the main river passage can be followed for another half mile to Sump Two. Over the whole length it maintains its grand proportions with most of the river deep enough and swift enough to prevent it being traversed without ropes. Three inlets join the river and all provide access to the cave river from the alluvial plain to the north. The inlet passages are mostly modified canyons with fault guided roof rifts and are nowhere less than comfortable walking size. On the south side of the river, Trumpet Parade is a fine 15 feet diameter abandoned phreatic tube which represents the downstream continuation of the fossil roof passages in Arrow Inlet. From it, access can be gained to the complex series of bedding and fault guided Upper Rifts, which loop back to the river passage via a narrow slot and could even yield a bypass to Sump Two.

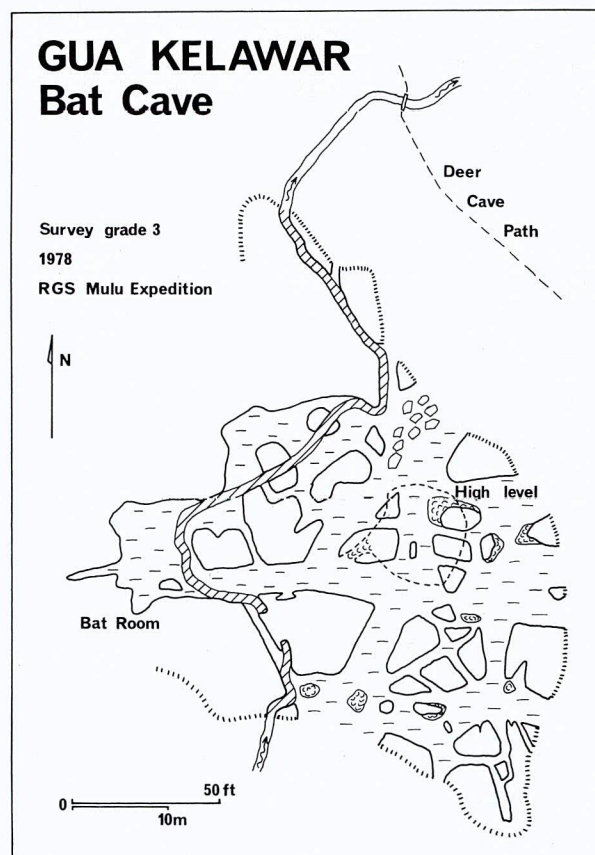
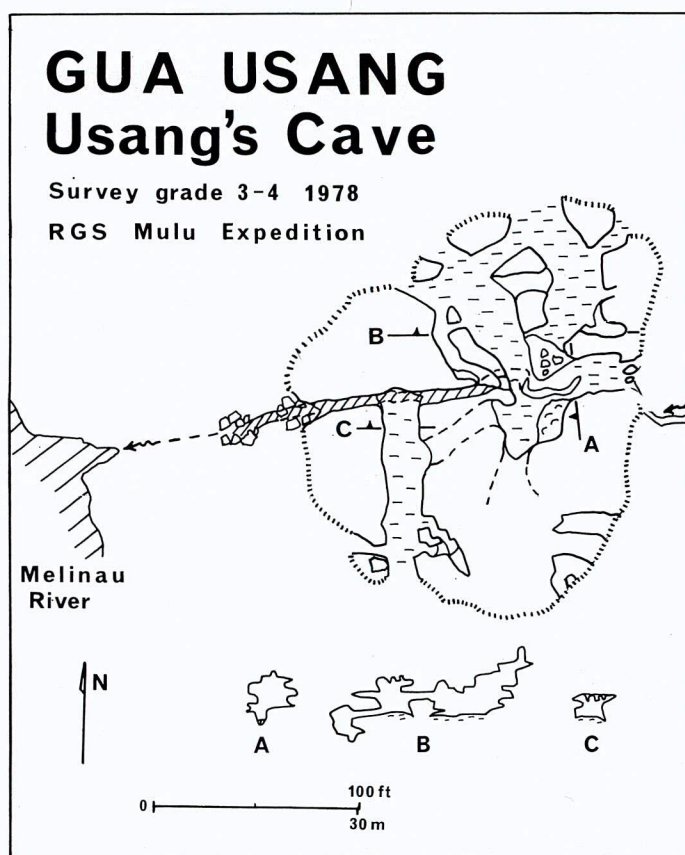
The continuation of the river passage, beyond Sump Two, can only be reached by yet more inlets from the alluvial plain. Nine Inlet is the easiest entrance to the East Cave, the longest of the three Terikan Caves with nearly two and a half miles of explored passage. This length includes two more stretches of the river passage. Between Sumps Two and Three the river is swift flowing in a large tunnel, with some rapids over boulders in a wide roof-collapsed hall. Towards Sump Four the river is more ponded and just before the sump there is a low arch to break the mainly high roof of the gallery. North Branch is an oxbow almost as large as the main river passage except for a considerable quantity of sand fill. Normally it carries a tiny stream, but this increases to a 100 cusec river in times of flood – partly overflow from the river and partly rising from a sump beneath Clay Series.



Main river passage in Terikan River Cave West

The high level caves are most complex in the East Cave. Keyhole Series is a maze of phreatic tubes and horizontal water cut notches, which includes some magnificent keyhole passages with deep floor canyons. Three daylight shafts break the roofs of boulder-strewn chambers and are all clearly aligned on faults. The sand and mud floored phreatic tunnels of Fairway provide the greatest length of cave at any one fossil level, till they end in descending shafts, one to the North Branch and one blind. Clay Series and the tunnels beyond Bridge Pot represent two fossil levels, 40 and 60 feet above the active level, and both have roof access to Fault Gallery, but terminate in boulder chokes.

The various explored caves of the Terikan River clearly represent only a fraction of the caves which must exist beneath Gunung Benarat. In the river passage each sump is formed where the cave follows down dip and then rises on a joint or fault. Sump Four is probably only short, and access to the river beyond can almost certainly be gained by following inlets from the alluvial plain east of the ends of Fault Gallery. With the mazes of fossil passages and the sporting challenge of the swift flowing underground river, the Terikan River Caves are already a fine series, and could be explored in the future into a magnificent integrated system.



BUKIT LUBANG – The Hill Caves

Completely in contrast to the linear passages of the major cave systems are the extremely complex mazes of the hill caves. Close to Long Pala four of these small limestone hills are each riddled with caves, formed where older levels of the Melinau River laterally corroded their bases – as the river is currently doing in Batu Pala, the right bank hill at Long Pala itself.

Half a mile downstream of Long Pala, Usang's Cave lies in a left bank hill. Three levels of passages exist in the cave and the lower one has been invaded by a small modern stream. The cave levels are restricted within five major wall grooves which are each continuous through the cave and must relate to old flood plain levels.

The left bank hill at Long Pala contains Bat Cave. This is a similar maze, again invaded by a stream cutting into the mud floors. It is however only on one level except for a single high-level chamber which is profusely endowed with stalagmite. The survey shows that well over half of the rock has been removed from the main level at the eastern end of the hill; it would seem that hill collapse is the inevitable result of continued cave development of this type.

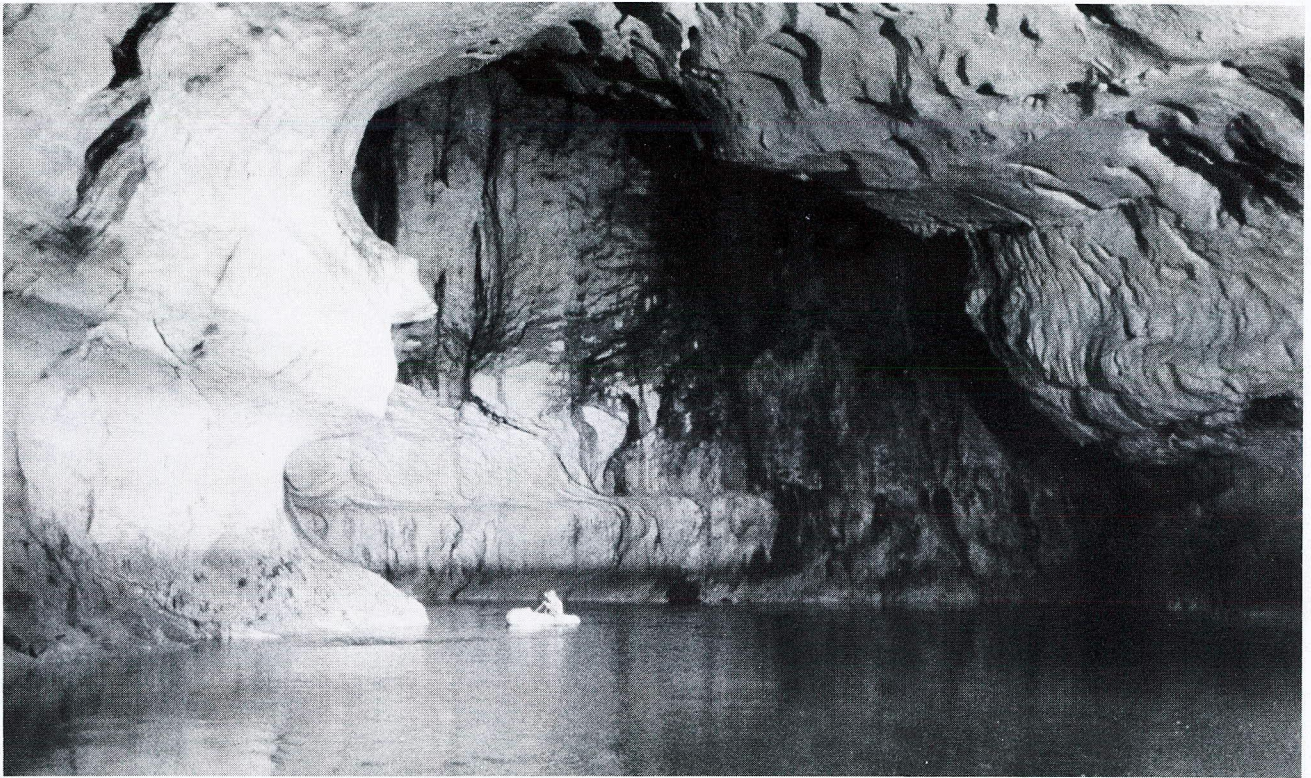
THE ORIGIN OF THE CAVES

The limestone hills of the Mulu Park have all the classic features which lead to successful cavern development. All the caves have been formed by running water – both the enormous rainfall on the limestone itself and also a large share of the surface water draining down from the slopes of Mulu. The water has then found a ready exit into the low-lying valleys of the Tutoh and Melinau – and such rapid, steeply graded drainage right through the limestone provides the optimum environment for cave development. To that extent, the caves of Mulu are like most other caves in the world, but in addition they do have their own distinctive features.

A first consideration of the caves must be how they fit into the regional geomorphology. Even this is complicated by the fact that many of the caves are very old. An exact age cannot be ascribed to them, but a million years is not untenable for the oldest; and in that time a vast amount of surface erosion has taken place. It is likely that the individual hills, Api, Benarat, Berar etc., are isolated reef masses of limestone, while shale floors in the Melinau Gorge and Hidden Valley suggest that they are exhumed features.

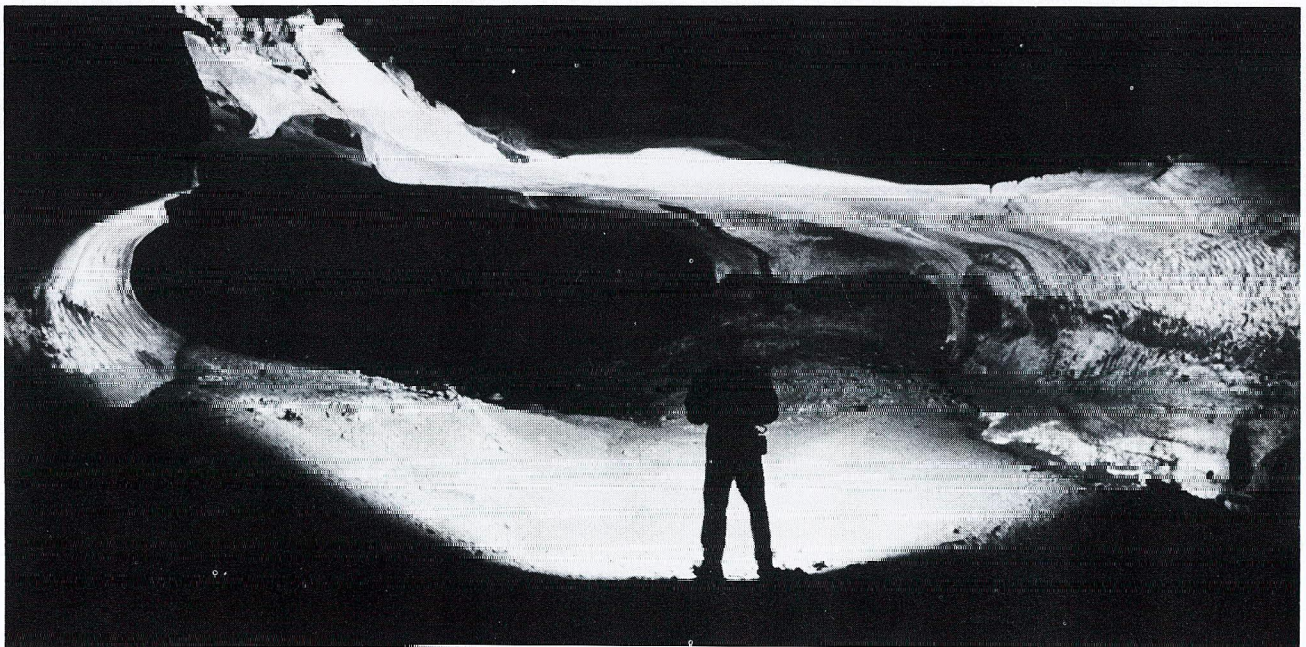


The delicate calcite fans – splash deposits in Wonder Cave



Wall notches indicate past levels of river erosion in the Clearwater Cave's main river passage

Each hill therefore has its own discreet hydrological system – except that the Melinau Paku valley appears to be a late incision separating the Deer Cave Hills from Api. The Melinau, Hidden Valley and Melinau Paku rivers seem to have played major roles in the early development of the caves. Melinau water was probably responsible for the vast old tunnels of Clearwater Cave, while the other rivers fed an ancient cave system of which fragments are now seen as Prediction, Green and Deer Caves. All this early development was orientated towards the Tutoh valley, as the Melinau plain, to the northwest, had not yet been cut down to anything like its modern level. But the younger phases of cave development have been orientated towards the presently more favourable low levels of the alluvial plain. This exchange of roles as the major local surface feature – from the Tutoh to the Melinau – accounts for the fact that all the caves have their main fossil passages disregarded by the cross-cutting modern drainage, as is so clearly demonstrated by the underground course of the Clearwater River.



The old phreatic tunnel of Sheer Delight in Clearwater Cave

Because of the towering isolation of the limestone hills, nearly all the major caves are now in the freely drained vadose zone, but this has not always been so. The long, nearly horizontal, fossil tunnels suggest shallow phreatic development. Also the many horizontal water-cut notches in the cave walls – for example, right through Deer Cave and Cave of the Winds – prove the importance of solutational activity at water levels, in turn representing past and present levels of the alluvial plain. On the other hand, Tiger Foot, Clearwater and Wonder Caves each contain contemporaneous phreatic passages exhibiting considerable vertical range, and the Melinau Gorge appears to have truncated a very deep phreatic zone. As yet, the exact positions and depths of past phreatic zones cannot be accurately determined, but the major importance of shallow phreatic development is already adequately demonstrated.

Within these hydrological constraints, the geological structures of the limestone have strongly influenced the caves. Most of the large tunnels follow the strike of the bedding which generally dips 20-40° to the north-west. Nearly all the other passages follow joints, faults or bedding planes, the major exceptions being the modern Clearwater and Terikan River Passages which cut the bedding as they follow the hydrological guidelines.

On the smaller scale, the Mulu caves provide an equally fascinating picture. The intricate and razor-sharp fretting of the rock in the Clearwater River Passage almost complements the wild rock sculpture of the pinnacles on the surface above. A hitherto undiscovered form of limestone weathering has been recognised in the entrance zones of Green Cave and elsewhere; photokarren consists of solutational slots inclined at around 45° and all orientated towards the sunlight from the cave entrance which controls the plant growth on the rock. Deep inside Wonder and Tiger Foot Caves, delicate calcite fans appear to be a previously unknown type of splash deposit, and those in Wonder Cave are just the strangest among an amazingly rich variety of cave decorations.

Much more is to be learned about the geology of the caves of Mulu. At present the framework of cave development in the area can begin to be elucidated, and already the caves have yielded a wealth of fascinating data. But future discoveries in Mulu will lead to an ever more precise understanding of what is one of the world's great cave regions.



An inhabitant of Bat Cave

THE CAVE LIFE

The visitor to the caves of Mulu is at once struck by the superabundance of living creatures. Most obvious are the cave swiftlets which roost in their tens of thousands in each of the major caves. These are not the edible-nested swiftlets of the Niah Caves, but close relatives which build their nests of moss glued together with sticky saliva. Within the nest are laid two tiny white eggs which hatch into voracious chicks. Around dusk the entrance passages are filled with the sound of fluttering and clicking as the birds echo-locate their way to the remote roost after a day spent foraging for insects above the lowland forest.

In Deer Cave the swiftlets are vastly outnumbered by huge roosts of freetailed bats. On most evenings close to a third of a million bats leave the southwest entrance in huge wheeling flocks or long sinuous clouds, accompanied by a great whooshing roar of thousands of pairs of wings, which can be heard two miles away at Long Pala. The acrid smell which wafts out of the cave is due to the high ammonia content of the bats' excreta, or guano. Fortunately the more unpleasant patches can be avoided by visitors, but they are actively sought out by a wide variety of less squeamish creatures such as cockroaches, beetles, flies and moths. The latter are surprising in that not only do their caterpillars eat guano and build cases of it in which they live, but the adults are repelled by light. Two of the more unusual guano bed inhabitants are long, slender centipedes which produce a bright green phosphorescent trail when annoyed, and oily-smelling giant earwigs which really belong in the roof of the cave where they graze on dead skin cells of roosting bats. Frantic to regain their lost hosts, the earwigs clamber up any available support – including passing humans.

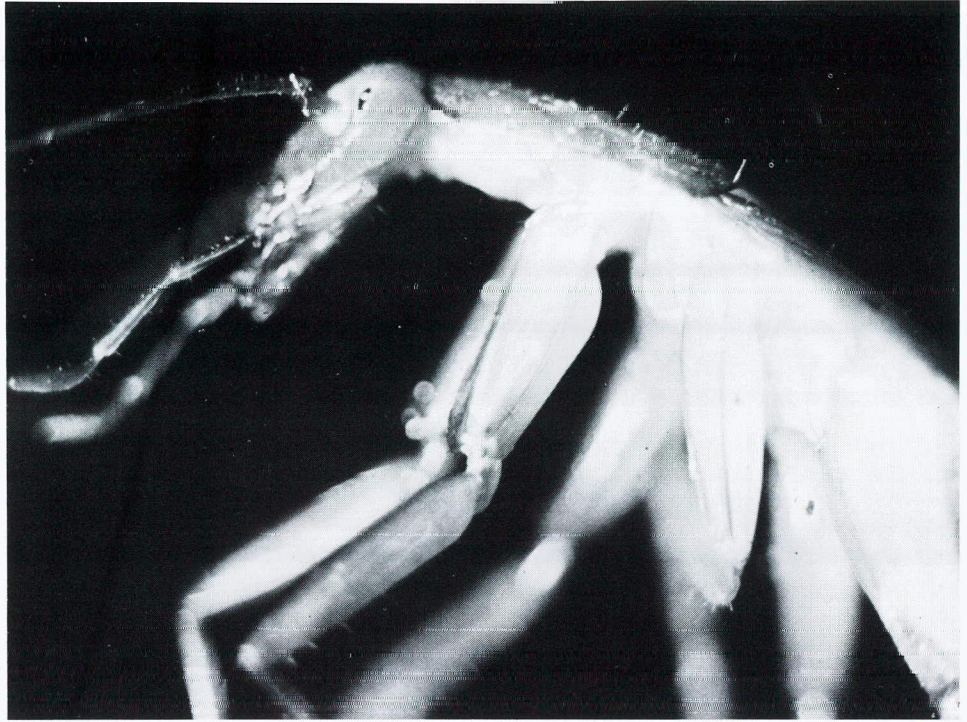
All of these creatures are part of the complex guano bed community where each animal holds its own place in the struggle to eat and to avoid being eaten. In Deer Cave the dominant predators are very large, fast-running centipedes with extremely long legs and poison claws set below the head. As they are up to eight inches long it is fortunate that they are shy of man and run away from light. In the swiftlet-occupied caves their place is taken by fearsome huntsman spiders which manage to catch their favourite food, a type of large meaty cricket, despite the latter's early warning system – a pair of constantly waving antennae, 18 inches long. The bats and swiftlets have their own predators, black and white striped snakes up to eight feet long, which creep up on their prey as they sleep suspended from the ceiling of the cave, or even ambush them as they fly through constricted passages.



A swiftlet chick on its nest a mile underground will never see daylight until it has learned to fly

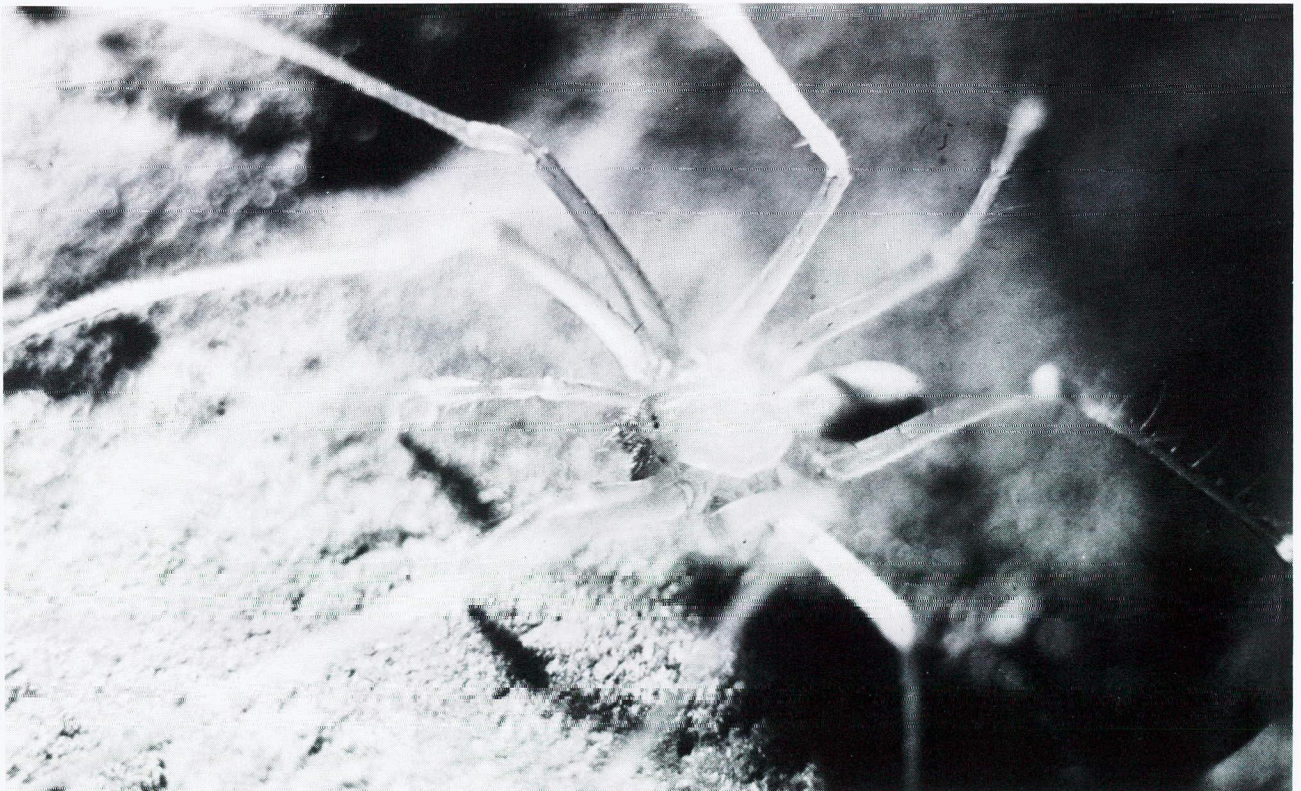


In the roof of Bat Cave, a snake has caught a sleeping bat almost too large for it to swallow

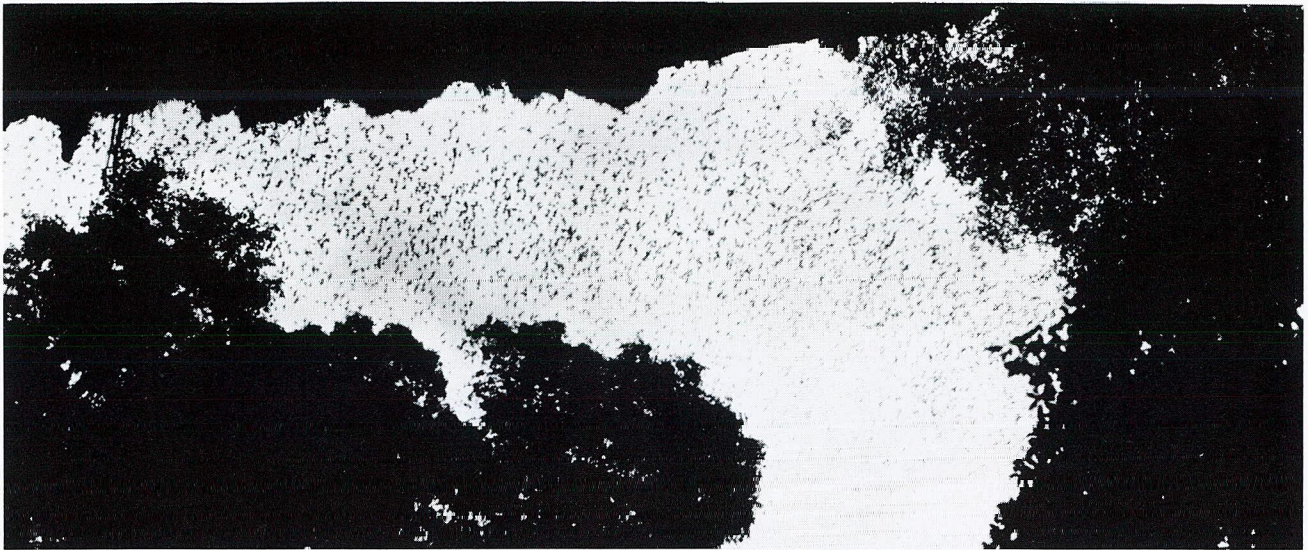


Cockroach from the deep cave community

But the animals which have really made the caves their own are small, delicate, retiring creatures found in remote passages, well away from the fierce struggle of the over-populated guano beds. Among these are minute, delicate white shrimps and isopods, eyeless white crabs, tiny blind beetles and unearthly-looking cockroaches. They form their own deep-cave community, simpler than that of the guano beds, but with similar types of animals in the key positions. The dominant predator is again a huntsman spider, but it is smaller, more fragile, creamy-white in colour, and probably blind. Even so, it is fearsome to its prey, and is a prime example of how the animal life has adapted to the sunless environment deep within the caves of Mulu.



Unable to see its prey, the cave spider relies on touch, using its first pair of legs as feelers



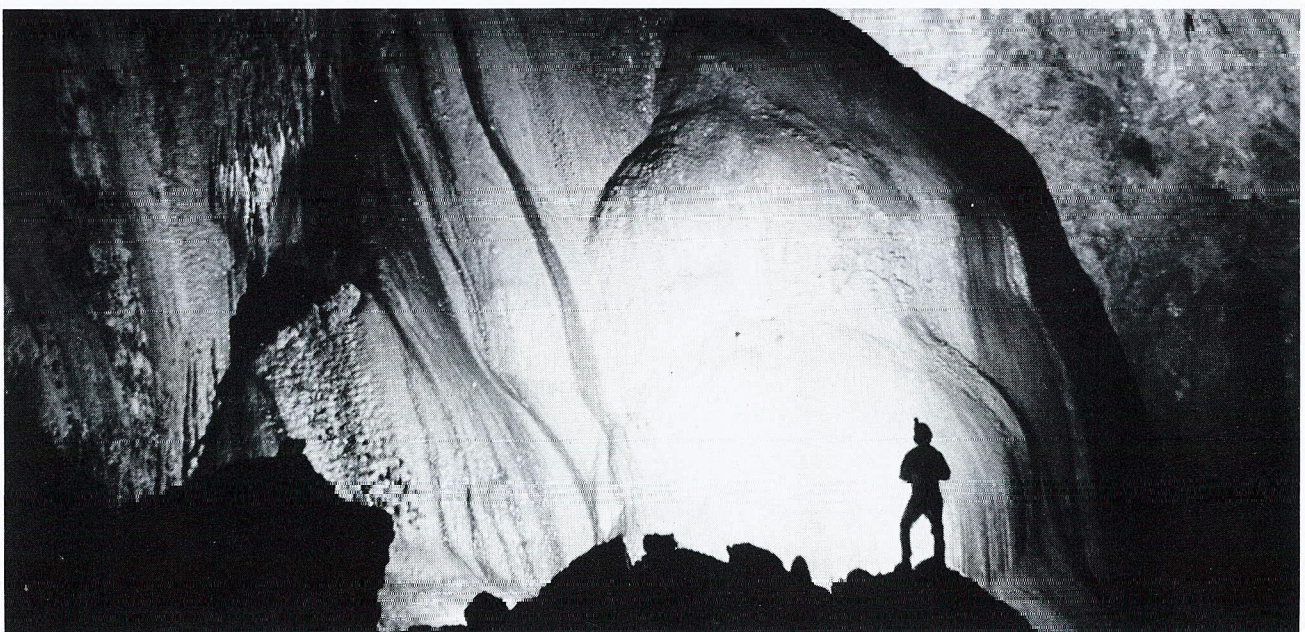
Thousands of bats on their nightly pilgrimage stream out of the southwest entrance of Deer Cave

ACKNOWLEDGEMENTS

The exploration, survey, photography and study of the caves of Mulu was the combined work of the Speleological Team of the Royal Geographical Society — Sarawak Government Expedition to Gunong Mulu. This team consisted of Dave Brook, Phil Chapman, Andy Eavis, Mike Farnworth, Ben Lyon and Tony Waltham, and the entire team has contributed to this publication. In addition, the team was joined in the field by Martin Lavery of the expedition's geomorphological group.

The Sarawak Government cooperated in many ways, and we thank Joseph Yong, Director of Forests, for permission to visit and work in the Park. Due credit is afforded to John Hemming, Director of the Royal Geographical Society, and the organising committee of the expedition, and in particular to Robin Hanbury-Tenison, leader of the expedition, and Nigel Winser, the senior field assistant. Financial support for the speleological team was gratefully received from the Sports Council of Great Britain, the Winston Churchill Memorial Trust, the Mount Everest Foundation and the Ghar Parau Foundation. The team acknowledges the support of its many commercial sponsors, notably Banton & Co. Ltd., Beaufort Ltd., Bradspout Ltd., Bridon Fibres and Plastics Ltd., The British Van Heusen Co. Ltd., Caving Supplies, Clogwyn Climbing Gear Ltd., Damart Thermawear Ltd., Edelweiss, Functional Clothing Ltd., W. L. Gore & Associates (U.K.) Ltd., H. J. B. Plastics Ltd., E. V. Hawtin Ltd., Hiatt & Co. Ltd., Hilti, Karrimor International Ltd., Ladysmith Busywear Ltd., Laughton & Sons Ltd., Leeds Metal Spinning Co. Ltd., Rabone Chesterman Ltd., Ralph Martindale Ltd., The Premier Lamp Co., Transatlantic Plastics Ltd., Troll Products Ltd., and Whernside Cave & Fell Shop. In addition, grateful thanks are also owed for the generous assistance of the other members of the expedition, and the invaluable friendship of the local people of Mulu.

Credits for the photographs are to: Dave Brook (25, 27, 29t) Phil Chapman (22/3, 22/5, 23/11, 42, 43tl, 43tr, 43br), Andy Eavis (f.c., 2, 9, 10bl, 10br, 17, 18t, 18b, 19, 20t, 22/4, 23/12, 23/15, 24, 26, 28, 29b, 30, 39, 40t, 44t, 44b), Mike Farnworth (22/1), Ben Lyon (23/8, 33, 34) and Tony Waltham (4, 6, 10t, 11t, 11b, 12, 15, 16, 20b, 21, 22/2, 22/6, 22/7, 23/9, 23/13, 23/14, 35, 37, 40b, 41, b.c.). The surveys are the work of the entire team but the drawings are by the editors.



Massive flowstone blocks the end of Moulin Rouge in Wonder Cave

